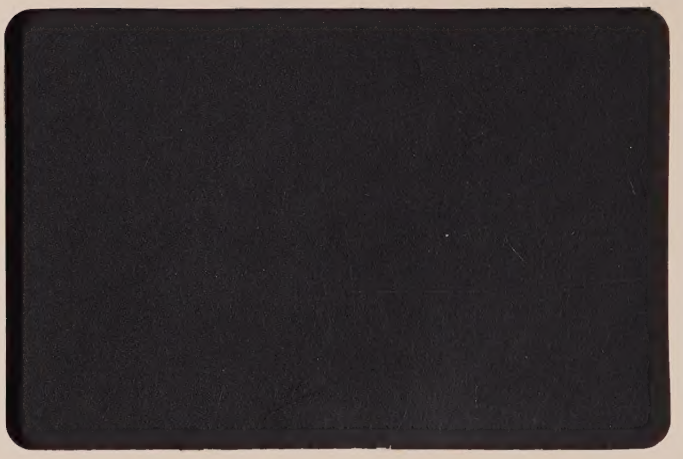
USATSG LIBRARY
FILE COPY

Holt Instrument Laboratories

OCONTO • WISCONSIN • 54153 • PHONE: 414 834-2222

DESIGNERS & MANUFACTURERS OF ELECTRONIC INSTRUMENTATION



OPERATING AND SERVICING

MANUAL

FOR

AC–DC THERMAL VOLTMETER STANDARD

MODEL 10

THIS MANUAL TO ACCOMPANY

INSTRUMENT NO. - 104 - - -

APRIL 1967

HOLT INSTRUMENT LABORATORIES

OCONTO, WISCONSIN

TABLE OF CONTENTS

Paragraph No.		Page No.
	SECTION 1 - INTRODUCTION	
1.1	General Description	1-1
	Technical Specifications	1-2
	SECTION 2 - OPERATING INSTRUCTIONS	
2.1	Preparation for Use	2-1
2.2	Operating Controls	2-1
2.3	Applications	2-4
	SECTION 3 - THEORY OF OPERATION	
3.1	General Theory	3-1
3.2	Basic Circuit Theory	3-1
3.3	Attenuator Circuit	3-2
3.4	Standardize Circuits	3-2
3.5	Reference Supply	3-4
3.6	Oven Circuits	3-5
3.7	Protective Circuits	3-5
3.8	Null Detector	3-7
3.9	Power Supply	3-8
	SECTION 4 - RECALIBRATION	
4.1	Recommended Test Equipment	4-1
4.2	Preliminary Check	4-1
4.3	Calibration Procedures	4-7
	SECTION 5 - SERVICING	
5.1	Voltage Measurements	5-1
5.2	Conditions for Voltage Measurement	5-1
5.3	DC Voltage Measurements	5-1
5.4	AC Measurements and Waveforms	5-1
5.5	Component Locations	5-1
5.6	Servicing Procedures	5-1
5.7	Service Procedures	5-1
	SECTION 6 - LIST OF REPLACEABLE PARTS	
6.1	Parts Numbers	6-1
6.2	Parts Description	6-2

LIST OF ILLUSTRATIONS

Figure No.	Title	Page No.
1	AC-DC Thermal Voltmeter Standard Model 10	1-1
2	Operating Controls and Indicators	2-2
3	Voltage Calibration	2-4
4	Typical Test Set-up Using the Model 10 as a Thermal Transfer Voltmeter	2-4
5	Operating Principle of the Model 10	3-1
6	Block Diagram of the Model 10	3-2
7	Simplified B Standardize Circuit	3-3
8	Simplified C Standardize Circuit	3-3
9	Thermoelement Circuit - D Standardize Position	3-3
10	Simplified D Standardize Circuit	3-4
11	Reference Supply Circuit	3-4
12	SCR Protection Circuit	3-5
13	Overload Relay Circuit	3-6
14	Null Detector Block Diagram	3-7
15	Power Supply Regulator Block Diagram	3-8
16	Frequency Response Calibration Set-up	4-4
17	400 Hz AC/DC Difference Calibration Set-up	4-5
18	Front Panel Detail No. 1	6-3
19	Front Panel Detail No. 2	6-3
20	Rear Panel Detail No. 1	6-4
21	Rear Panel Detail No. 2	6-4
22	Right Panel Detail	6-6
23	Main Attenuator Detail	6-8
24	0.001 Volt Decade Board Detail	6-8
25	Relay Protection Circuit Board Detail	6-14
26	Relay Protection Circuit Attenuator	6-14
27	Main Circuit Board Detail No. 1	6-16
28	Main Circuit Board Detail No. 2	6-16

LIST OF ILLUSTRATIONS CONT.

Figure No.	Title	Page No.
29	+ 60 VDC Power Supply Board Detail	6-20
30	Reference Oven Board Detail	6-22
31	Thermal Converter Oven Board Detail	6-26
32	Null Detector Power Supply Board (Detail 1)	6-28
33	Null Detector Power Supply Board (Detail 2)	6-28
34	Null Detector Amplifier Board (Detail 1)	6-32
35	Null Detector Amplifier Board (Detail 2)	6-32

ADDENDUM

1 May 1967

MODEL 10 MANUAL

Add to Parts List:

R454*	Resistor, Metal Film, 909 Ohms, 1/2 Watt, 1%	0804-114	IRC CEC-TO	28
C405*	Capacitor, Mica, 500 Volts 160 pf, ± 1%	0907-053	Arco DM15-161 EI	28
C216*	Capacitor, Mica, 500 Volts 1 pf, ± .5 pf Placed in parallel with R210 as a frequency adjustment.	0907-072	Arco DM15-010M	

The following warning should be added to Section 2.2 b:

WARNING!

Do not attempt to switch the FUNCTION switch from the input connector to STANDBY if the input voltage exceeds 500 VAC at frequencies greater than 50 kHz. Decrease the input voltage to below 500 VAC before switching under these conditions.

Digitized by the Internet Archive
in 2025

https://archive.org/details/manualsplus_07734

CLAIM FOR DAMAGE IN SHIPMENT

The instrument should be tested as soon as it is received. If it fails to operate properly, or it is damaged in any way, a claim should be filed with the carrier. Also, notify Holt Instrument Laboratories or the local representative immediately. A full report of the damage should be obtained by the claim agent and this report should be forwarded to us. We will advise you of the disposition to be made of the equipment and arrange for repair or replacement. Include model number and serial number when referring to this instrument for any reason.

WARRANTY

Holt Instrument Laboratories warrants each instrument manufactured by them to be free from defects in material and workmanship. Our liability under this warranty is limited to servicing or adjusting any instrument returned to the factory for that purpose and to replace any defective parts thereof. Electron tubes, fuses, and batteries are specifically excluded from any liability. This warranty is effective for one year after delivery to the original purchaser when the instrument is returned, transportation charges prepaid, and when upon our examination it is to our satisfaction defective. If the fault has been caused by misuse or abnormal conditions of operation, repairs will be billed at cost. In this case, an estimate will be submitted before the work is started.

If any fault develops, the following steps should be taken:

1. Notify either the factory or the area Holt representative, giving full details of the difficulty, and include the model and serial numbers. Upon receipt of this information we will give you service data or shipping instructions.

2. On the receipt of shipping instructions, forward the instrument prepaid to the factory or the authorized repair station indicated in the instructions. If requested, an estimate of the charges will be made before the work begins is such work is not covered by warranty. All shipments of Holt Instrument Laboratories' equipment should be packed in a strong exterior container surrounded by two or three inches of shock absorbing material.

SECTION 1

INTRODUCTION

1.1 General Description

a. The Holt Thermal Voltmeter Model 10 is an RMS reading, differential thermoelement voltmeter with broad voltage and frequency range. The Model 10 provides NBS Traceable precision AC voltage measurement for use at secondary reference laboratories and secondary transfer field laboratories. The instrument is capable of measurement in the direct reading or transfer modes for both AC and DC voltages.

b. The Model 10 contains a solid state null detector capable of high resolution under all ambient light conditions and in all physical positions.

c. The Model 10 is equipped with a direct reading, 6 digit in-line readout providing continuous coverage of the RMS input voltage magnitude from 1.000 to 1111.110 volts. Extremely low reversal error (less than ± 0.001%) eliminates the necessity to reverse the DC input or to calculate DC reversal error correction factors.

d. The Model 10 has been designed to operate over a broad frequency range. This allows its use as a standard in determining the influence of frequency on less sensitive devices. The usable range of the Model 10 is from a minimum frequency of 20 Hertz up to a maximum of 1 M Hertz.

e. The Model 10 is equipped with a fully protected input thermoelement. This protective circuitry virtually eliminates expensive thermoelement burnout and time consuming replacements. The protective circuit is capable of protecting the input thermoelement against overloads up to 1500 volts AC or DC. This feature permits the use of the instrument outside of the standards laboratory by relatively unskilled personnel.

f. The internal wiring associated with the low-potential thermoelement circuits and the sensitive null detector amplifiers employ unique low thermal EMF techniques, junction pairing and heat sinking for the ultimate stability regardless of varying ambient temperatures.

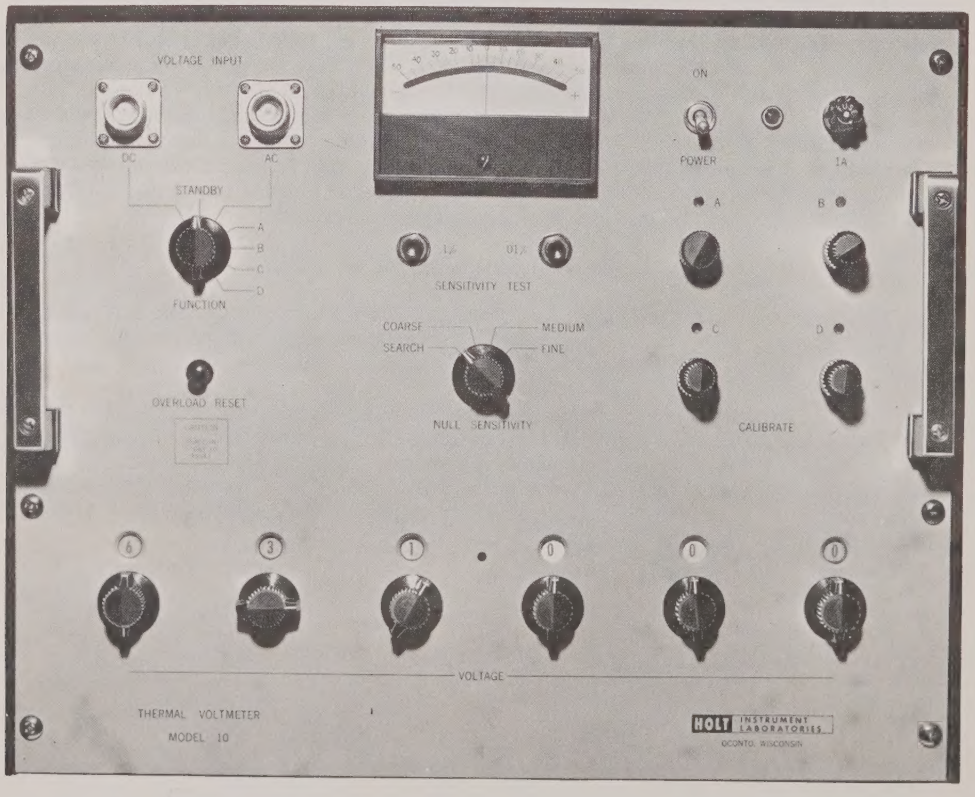


Figure 1. AC-DC Thermal Voltmeter Standard - Model 10

TECHNICAL SPECIFICATIONS

OVERALL VOLTAGE RANGE: Continuous coverage from 1.000 to 1111.110 volts.

FREQUENCY RANGE: DC and 20 Hz to 1 MHz.

ACCURACIES:
(Including stability for 6 months)

Direct Reading Voltmeter		AC/DC Transfer
0.010% (+ 25 microvolts) - DC voltage	1-1111.110 volts	0.015% - 20 Hz to 1 kHz
0.020% - 20 Hz to 10 kHz	1- 700 volts	0.015% - 1 kHz to 10 kHz
0.025% - 20 Hz to 10 kHz	700-1111.110 volts	0.020% - 1 kHz to 10 kHz
0.030% - 10 kHz to 20 kHz	1-1111.110 volts	0.020% - 10 kHz to 20 kHz
0.040% - 20 kHz to 30 kHz	1- 700 volts	0.040% - 20 kHz to 30 kHz
0.050% - 20 kHz to 30 kHz	700-1111.110 volts	0.040% - 20 kHz to 30 kHz
0.110% - 30 kHz to 50 kHz	1- 700 volts	0.080% - 30 kHz to 50 kHz
0.150% - 30 kHz to 50 kHz	700-1111.110 volts	0.100% - 30 kHz to 50 kHz
1.000% - 50 kHz to 300 kHz	1 - 100 volts	0.950% - 50 kHz to 300 kHz
0.150% - 50 kHz to 100 kHz	1 - 200 volts	0.100% - 50 kHz to 100 kHz
0.500% - 50 kHz to 100 kHz	1-1111.110 volts	0.450% - 50 kHz to 100 kHz
0.500% - 1 MHz	1 volt	0.450% - 1 MHz

REVERSAL ERROR: Inherent 0.01% maximum. Adjustable to .001% maximum.

INPUT RESISTANCE: 167 ohms/volt.

STABILITY: Short Term: Null one minute after application of unknown voltage. Remains within .005% of null for 20 minutes.
Long Term: (Included in accuracy specification)
Direct Reading Voltmeter ± 0.005% for six months.
AC/DC Transfer ± 0.004% for six months.

NULL DETECTOR: All solid state circuitry. 50 scale divisions either side of zero. Sensitivity - .001% per minor division.

AMBIENT TEMPERATURE COEFFICIENT: Less than ± .001% (10 ppm) per degree Centigrade.

OPERATING ENVIRONMENT: Temperature +5° to +45° C.
Humidity: 10% to 90%.

OVERLOAD PROTECTION: Push button resettable. Fully protected for any overload up to 1500 volts.

RELIABILITY: 2000 hours MTBF.

INPUT POWER: 105-125 volts / 50-60 Hz.

WEIGHT: 38 lbs. Bench Model.

MECHANICAL: Bench Cabinet: 17-1/8" W x 18" D x 14" H Maximum.
Rack Mount: 19" W x 18" D x 14" H Maximum.

SECTION 2

OPERATING INSTRUCTIONS

2.1 Preparation for Use

a. General. The Model 10 is supplied factory tested and calibrated in a single shipping container. The customer need only make the power connections as indicated below. The Model 10 should require no preliminary service by the customer.

b. Power Connections. The power cord is terminated in a 3 prong male connector. Viewing the connector from the pin end with the round pin at the top, the left hand pin is connected to common, the right hand pin to the hot side of the line and the round pin to chassis. It is important that the chassis be connected to a good earth ground either directly through the power plug or indirectly through the earth connection of the system in which measurements are being made. Large amounts of noise or 60 cycle voltage on the instrument chassis may affect the accuracy of the readings. Be sure the power switch is in the OFF position before inserting the line plug. A three wire to two wire line adapter is provided to allow isolation of the Model 10 from earth ground when the earth ground connection is made elsewhere in the measurement system.

c. Power Line Voltage. The instrument is designed for operation on a line voltage of 115 volts AC (± 10 volts) at a line frequency of 50 or 60 Hertz. Power consumption is 30 watts. A line fuse is located in the upper RH corner of the front panel (see Figure 2).

2.2 Operating Controls

The controls and terminals located on the front panel are described below. These are the controls used in the normal operation of the Model 10. The internal controls and adjustments used in the calibration of the instrument are covered in the appropriate maintenance section of this manual.

a. POWER SWITCH. This switch turns on the indicator light, null detector, internal reference, and other internal circuitry. The Model 10 employs a highly stable reference diode enclosed in a temperature controlled oven. The differential thermoelements are also enclosed in an oven. Although accurate measurements may be made with the instrument within a few moments after it is turned on, in a 25° C ambient environment a warm-up period in excess of 30 minutes is required before the instrument can be expected to meet its drift specifications.

b. FUNCTION SWITCH. This 7 position switch selects the two input circuit connections; a standby position; and 4 positions used to standardize or balance the internal circuitry of the instrument before readings are taken. These 4 standardize positions are labeled alphabetically A, B, C, and D. When the FUNCTION switch is in either of the standardize positions or in the STANDBY position, the heaters of both thermoelements are energized so that a minimum of time is required for equilibrium of the thermoelement EMF outputs when a measurement is made. If the input thermoelement is unenergized for an extended period while measuring the input voltage, a resettling time of one to two minutes should be allowed (to insure that the thermoelements have again reached thermal equilibrium) before high accuracy readings are attempted. The FUNCTION switch positions are used as follows:

In the DC position, the input circuitry is connected to the left hand DC VOLTAGE INPUT connector.

In the STANDBY position, the input circuit is open.

In the AC position, the input circuit is connected to the AC VOLTAGE INPUT connector on the right.

In the A position, the A indicator light is turned on and the A STANDARDIZE control is adjusted to null the meter.

In the B position, the B indicator light is turned on and the concentric B STANDARDIZE controls are adjusted to null the meter.

In the C position, the C indicator light is turned on and the concentric C STANDARDIZE controls are adjusted to null the meter.

In the D position, the D indicator light is turned on and the concentric D STANDARDIZE controls are adjusted to null the meter.

NOTE

In using the FUNCTION switch and the 4 standardize controls, it is essential that the controls be adjusted in alphabetical order only. The position of the NULL SENSITIVITY switch is not critical when standardizing.

c. NULL SENSITIVITY SWITCH. This switch has four positions marked SEARCH, COARSE, MEDIUM and FINE. Each position of the switch controls the relative sensitivity of the null detector. The SEARCH position is the least sensitive range and should be used when starting to null a new voltage to prevent overdriving the null detector. As balance is approached, the COARSE, MEDIUM, and FINE positions can be used. Always null to within 1/2 of 1 major division on the meter before

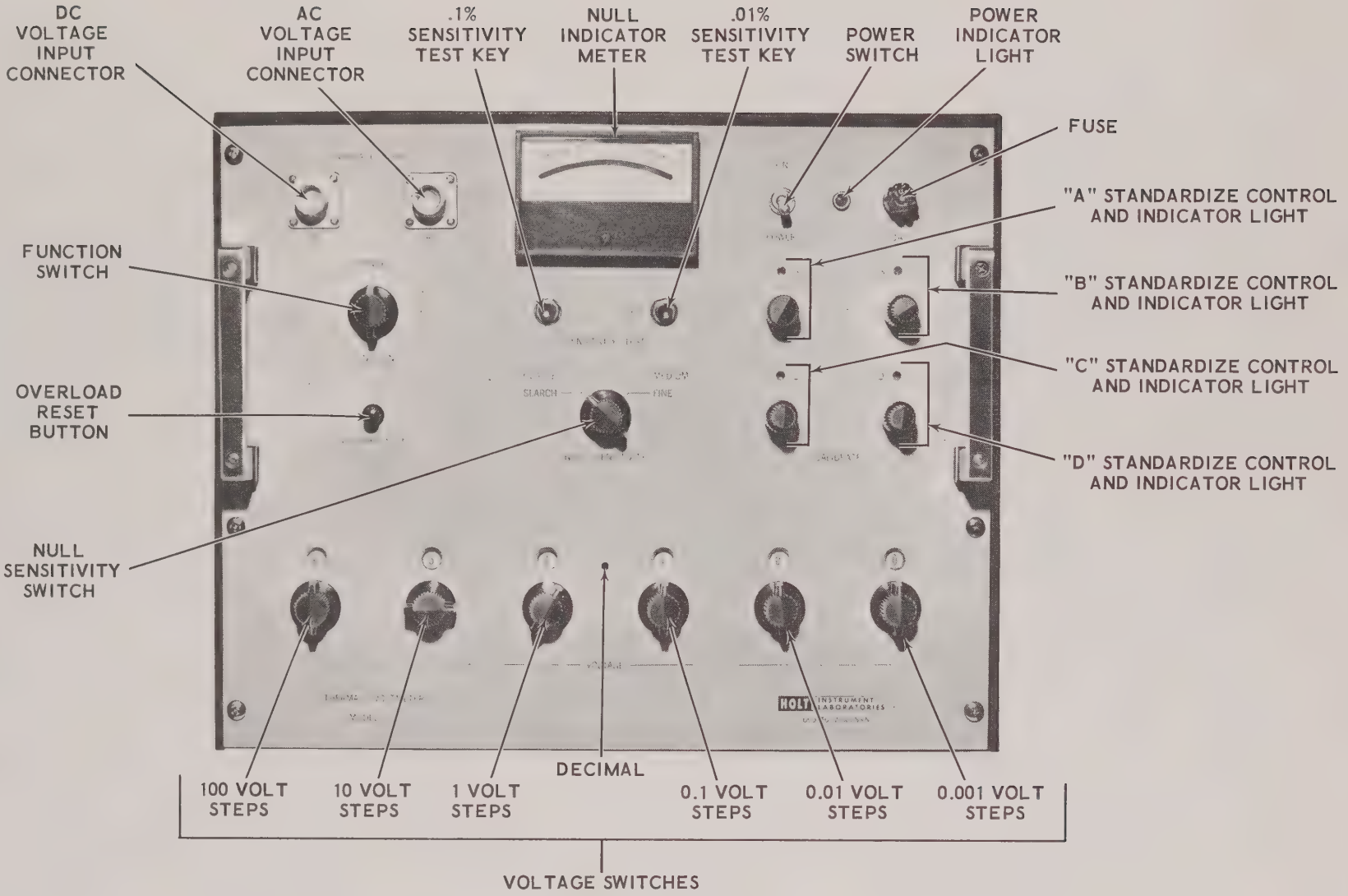


Figure 2. Operating Controls and Indicators

switching to the next more sensitive range.

When making measurements with the Model 10, the full scale (50 minor divisions) meter deflections in each of the null sensitivity positions are as follows:

SEARCH - 100% (approximate, not linear)
COARSE - 5% (approximate)
MEDIUM - 0.5% (approximate)
FINE - 0.05%

d. VOLTAGE CONTROLS. These 6 controls, each with its associated digital readout window are located across the lower section of the instrument panel. Each of these controls rotates a 10 position switch and also changes the number on its corresponding readout window. The controls are related to one another in a decade relationship and from left to right control hundreds, tens, units, tenths, hundredths and thousandths volts. To measure an unknown voltage, the instrument is first standardized as described in paragraph b. above. The VOLTAGE switches are set to a range near the expected magnitude of the unknown voltage. The NULL SENSITIVITY switch is set to SEARCH and the VOLTAGE switches are adjusted to null the meter, first in the SEARCH position, then in the COARSE, MEDIUM and FINE positions of the NULL SENSITIVITY control. When final null has been secured, the unknown input voltage may be read directly on the digital readout to the resolution of the VOLTAGE CONTROLS. At the lower voltages additional resolution up to 0.001% can be obtained by interpolating the meter indication at the null setting.

e. SENSITIVITY TEST KEYS. The two Sensitivity Test Keys are marked .1% and .01%. These keys provide a means of converting any given meter deflection to some known percent per division. To use, press the appropriate sensitivity key and note the null detector deflection. The deflections obtained by depressing the keys when the Function Switch is in the standardize positions have no significance.

$$\frac{\text{Sensitivity Test Key (\%)}}{\text{Resultant Meter Deflection (Divisions)}} = \frac{\text{\% Resolution}}{\text{Division}}$$

Example: Assume you have nulled an unknown voltage and now observe a change of 5 divisions on the meter. To convert this change to percent of the applied voltage, depress the .01% key and note the meter deflection. Assume it is 10 divisions. The formula above gives:

$$\frac{.01\%}{10 \text{ divisions}} = .001\% \text{ per division}$$

Hence the 5 division change originally observed is equal to .001 x 5 or .005%.

f. OVERLOAD RESET. The Overload Reset button will automatically pop up with an audible click when the Model 10 is subjected to overloads. Reset the overload relay by removing the overload (turn the FUNCTION switch to STANDBY) and depress the OVERLOAD RESET button until it clicks into place.

WARNING

Attempting to reset the overload relay without first removing the overload may damage the overload circuit, the attenuator resistors, and/or the SCR protection circuit. Always set the FUNCTION switch to STANDBY when resetting the overload relay.

g. VOLTAGE INPUT Connectors. The two VOLTAGE INPUT connectors provide the means for connecting the Model 10 to the AC or DC voltage under test.

h. STANDARDIZE Controls. The 4 STANDARDIZE controls are labeled alphabetically and are used with the FUNCTION switch to perform the initial standardization of the instrument before readings are taken. The controls are adjusted in alphabetical order, each control being used to null the meter, as the FUNCTION switch is turned in alphabetical order, and as its respective indicator light turns on. The B, C and D controls are concentric switches and rheostats to obtain a large control range with excellent resolution. The internal standardization performed by each control is as follows:

(1) A STANDARDIZE control adjusts the null detector circuit to correct for internal thermal EMF's and offsets.

(2) B STANDARDIZE controls adjust the balance thermoelement heater circuit resistance to a predetermined value.

(3) C STANDARDIZE controls adjust the input thermoelement heater circuit resistance to a predetermined value.

(4) D STANDARDIZE controls adjust the differential output EMF of the thermoelements to zero with equal current flowing in their heaters.

NOTE

It is essential that this sequence standardization be followed in alphabetical order. All 4 adjustments must be checked each time the instrument is standardized and the sequence of standardization must be alphabetical.

i. INDICATOR LIGHTS. There are 5 indicator lights on the front panel of the Model 10. One, located next to the POWER switch, serves to indicate when the POWER switch is on and power

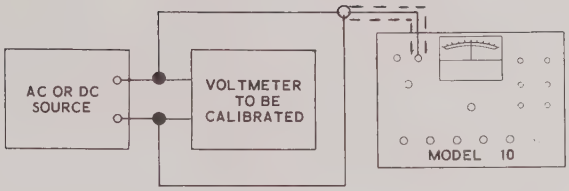


Figure 3. Voltage Calibration

is applied to the instrument. The remaining 4 indicator lights are labeled alphabetically A, B, C, and D and are controlled by the FUNCTION switch. They serve to indicate the proper control to be used to null the meter during the standardizing process.

2.3 Applications

a. Voltage Measurement. Obvious use of the Model 10 Thermal Voltmeter is in the standardization of unknown AC voltages to known levels for calibration of other indicating voltmeters. The accuracy specification of the Model 10 will allow its application with an AC voltage source to precisely calibrate VTVM's differential voltmeters, digital voltmeters, thermoelement voltmeters, dynamometers or virtually any AC voltmeter currently available.

The simplicity of operation, its protection against damage and its broad operating temperature range permit its use by relatively unskilled personnel outside of the environment of the standards or calibration laboratory.

In practice, the voltage to be measured is applied to an INPUT connector of the Model 10. See Figure 3. The instrument is standardized by turning the FUNCTION switch through the A, B, C, and D positions, and adjusting the proper STANDARDIZE controls to null the meter in each position. The FUNCTION switch is then set to the appropriate input connector position, the NULL SENSITIVITY is set to SEARCH, and the VOLTAGE controls are adjusted to null the meter. The process is repeated using the COARSE, MEDIUM and FINE positions of the NULL SENSITIVITY control. When a final null is secured in the FINE position, the RMS value of the unknown voltage may be read on the digital readout. At the lower voltages, additional resolution up to 0.001% can be obtained by interpolating the meter indication at the null setting.

b. Transfer Voltmeter. The Model 10 may also be used as a transfer voltmeter where a known voltage or one which can be easily measured is set equal to an unknown voltage by a transfer technique. When used as a transfer voltmeter, the Model 10 requires external adjustment as follows:

(1) DC Source. A stable DC source with variable output voltage is required.

(2) DC Measuring Equipment. The accuracy with which the DC voltage can be measured is a determining factor in the accuracy of the system. A standard cell, voltbox and potentiometer system is recommended.

(3) AC Source. A stable, adjustable, variable

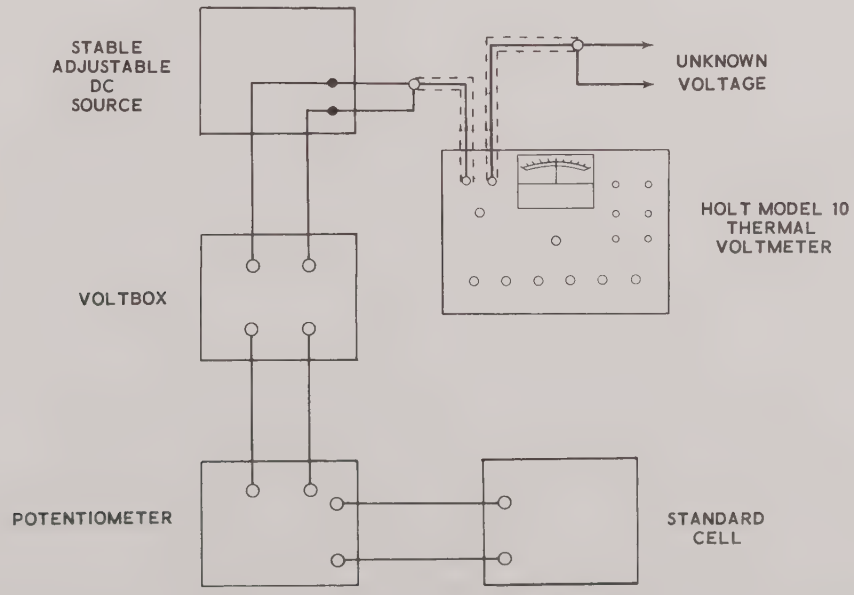


Figure 4. Typical Test Set-up Using the Model 10 as a Thermal Transfer Voltmeter

frequency AC source, such as the Holt Model 324 is required if calibration and frequency response measurements are to be conducted.

A diagram of a typical transfer system is shown in figure 4. The voltage to be measured is applied at the AC VOLTAGE INPUT connector of the Model 10. The DC voltage and its associated calibrating equipment (potentiometer, voltbox, and standard cell) are connected to the DC connector.

During a transfer measurement, the direct measurement capabilities of the Model 10 are not of basic importance. The important item is that the front panel meter be settable to a true null (zero) for the unknown voltage. The resolution of the VOLTAGE controls at the lower voltages does not allow a true null to be achieved. The D STANDARDIZE concentric controls when adjusted in conjunction with the VOLTAGE controls can be used as balance controls over a limited range to provide a true null with excellent resolution. However, it must be remembered that the unit must be restandardized before it can be used in the direct reading mode. The Model 10 is standardized, the FUNCTION switch is set to AC, and the VOLTAGE controls and D STANDARDIZE controls are adjusted to null the meter in the various sensitivity ranges until a final null is secured in the FINE position. The FUNCTION switch is then set to DC and the DC voltage source is adjusted until the same null is achieved, again in the FINE sensitivity position. The value of the DC voltage is then measured by accepted laboratory methods. The value of this DC voltage is then equal to the RMS value of the unknown voltage. Accuracy, of course, depends upon the specified accuracy of all the intervening instruments.

SECTION 3

THEORY OF OPERATION

3.1 General Theory

a. The fundamental theory upon which the Model 10 is based is that the RMS value of an alternating current has exactly the same heating effect as a like value of direct current. Thus, if a thermoelement junction is heated with a standardizing value of DC current and then reheated to exactly the same temperature with an unknown value of AC or DC current, there exists a one-to-one relationship between the RMS values of the standardizing current and the unknown current. If, in addition, the thermoelement heater circuit resistance can be adjusted to a predetermined fixed value, it is possible to construct a precision attenuator to be placed in series with the thermoelement heater circuit so that by equating the unknown current to the standardizing current there also exists a definite relationship between the voltage across the alternator-thermoelement heater circuit combination and the standardizing current.

b. The heart of the Model 10 is the vacuum thermoelement. This consists of a heater or heating element with a standard thermocouple junction attached to the heater with a small glass bead. The complete assembly is sealed in an evacuated container. The thermocouple junction senses the temperature of the heater and generates a voltage proportional to the temperature of the heater. The thermoelement is a low current device and is very sensitive to overload. In order to broaden the operating range of the thermoelement, suitable limiting resistors are employed to limit the current to the value required to heat the junction without overload.

c. The simplified diagram (figure 5) illustrates the basic theory employed in the Model 10. Heart of the instrument is the two thermoelement units TC701 and TC702. These are matched thermoelement units whose output EMF's are connected in series bucking with the null indicator. When these units are standardized to have a predetermined heater circuit resistance and are heated by exactly the same RMS value of current, they can be adjusted to have identical EMF outputs and the null indicator will show no current flow. If the balance thermoelement TC702 is now connected to a constant current source, it will have a constant EMF output which can be compared with the EMF output of the input thermoelement. The input thermoelement TC701 is connected in series with a 200 ohm per volt attentuator. When the unknown voltage is applied across this circuit of attenuator and thermoelement and the attenuator is adjusted to give a null on the null indicator, the current through the two thermoelements will be identical. Since the resistance of the input thermoelement TC701 heater circuit can be standardized to an exact predetermined value, by using a constant 200 ohms per volt attenuator it is possible to calibrate the attenuator in terms of input voltage.

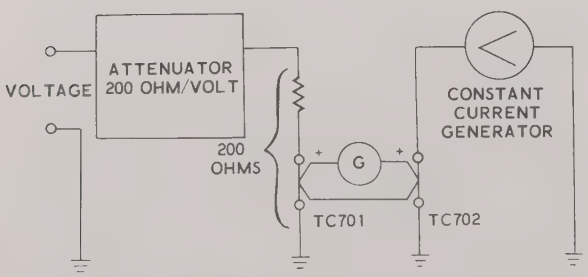


Figure 5. Operating Principle of the Model 10

3.2 Basic Circuit Theory

a. The block diagram (figure 6) illustrates the relationship of the six circuits which make up the Model 10. The voltage under test from the FUNCTION switch is applied to the main attenuator. This precision attenuator circuit relates the input thermoelement current to the input voltage during a measurement. The MAIN ATTENUATOR is controlled by the 6 VOLTAGE dials on the front of the instrument. The accuracy of this attenuator to a great extent determines the accuracy of the instrument. The overload relay protection circuit and the SCR protection circuit protect the input thermoelement in the event of overload. The standardizing procedure insures the following:

(1) The heater circuit resistance of the input thermoelement is a precision predetermined value to match the precision 200 ohms per volt main attenuator.

(2) A null is shown on the front panel meter when the input and balance thermoelements have exactly the same RMS value of heater current.

(3) The balance thermoelement is provided with an exact precision 5 milliampere DC in its heater circuit when a direct reading measurement is being made.

Therefore, during a direct reading measurement, if the VOLTAGE controls are adjusted to give a null on the front panel meter, the above statements show that the attenuator and input thermoelement current must be a precise 5 milliampere RMS. Therefore, the input RMS voltage is that shown by the VOLTAGE control settings.

b. The paragraphs which follow will each be devoted to discussion of the operating theory of one of the basic circuits that make up the Model 10. Refer to the block diagram, the simplified schematics

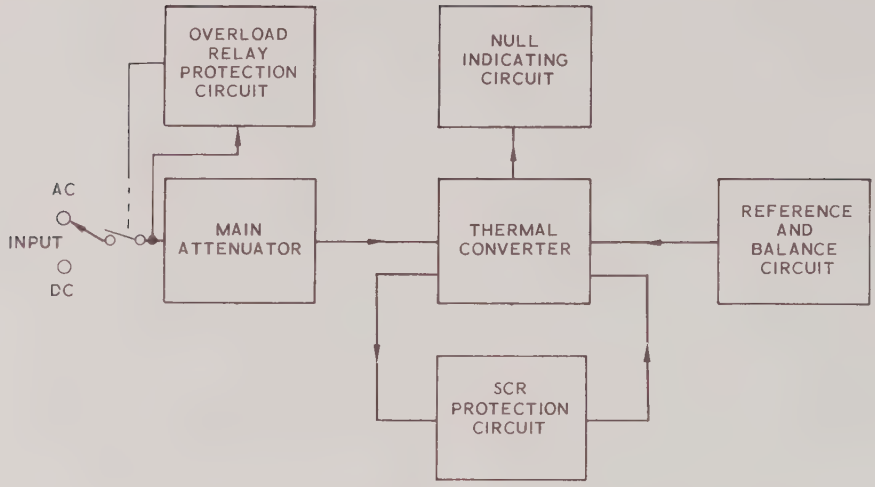


Figure 6. Block Diagram of the Model 10

or the complete schematics at the end of the text to better understand the function of each circuit and its use in the Model 10.

3.3 Attenuator Circuit

a. The main attenuator is used to relate the input thermoelement current to the input voltage and the VOLTAGE control settings. Use of high quality, stable, factory selected components is essential if high precision calibration is to be maintained. The schematic diagram titled, "Main Attenuator" illustrates the attenuator circuit.

b. The main attenuator is essentially a 200 ohm per volt attenuator. It is controlled by the six VOLTAGE switches located on the front panel. These switches are identified on the schematic diagram as follows:

S201 changes the voltage in steps of 100 volts and is arranged to switch resistance into the attenuator in steps of 20,000 ohms.

S202 changes the voltage in steps of 10 volts and switches resistance into the attenuator in steps of 2,000 ohms.

S203 changes the voltage in 1 volt steps and switches resistance into the attenuator in steps of 200 ohms.

S204 changes the voltage in 0.1 volt steps and switches resistance into the attenuator in steps of 20 ohms.

S205 changes the voltage in 0.01 volt steps and switches resistance into the attenuator in 2 ohm steps.

S206 changes the voltage in steps of 0.001 volt and through a series parallel combination of resistances with R254 and R255, changes the attenuator resistance in steps of 0.2 ohms.

Additional switch contacts between S205 and S206 provide logic switching over the entire voltage range of the instrument.

c. Frequency Compensation. In order to insure that the response is flat across the entire operating frequency range, additional contacts on switches S201 and S202 connect compensating capacitors into the attenuator on the 100 and 10 volt ranges as illustrated on the lower left hand corner of the schematic. The attenuator is frequency compensated during the factory calibration procedures and compensation will differ slightly from one unit to the next. The values of capacity shown on the schematic are nominal values.

CAUTION

Each Model 10 is individually compensated at the factory for the distributed capacity of its own wiring and components. Do not change the position of the wiring or of the components in the attenuator section. Any movement or replacement of parts or wiring may necessitate recompensation of the attenuator.

3.4 Standardize Circuits

a. General. There are 4 internal standardizing circuits in the Model 10. They are designated alphabetically as the A, B, C, and D standardizing circuits and are controlled by the FUNCTION switch. Standardization is performed in each case by nulling the meter with the A, B, C, or D STANDARDIZE controls as the FUNCTION switch is moved through the respective positions.

b. A STANDARDIZE Circuit. This circuit is designed to allow zeroing the front panel meter when the null detector input leads are shorted together by the FUNCTION switch. This procedure compensates for any thermal EMF's or offsets in the null detector circuit. The circuit consists only of the A STANDARDIZE control R140 which is connected to the null detector board.

c. B STANDARDIZE Circuit. This circuit is designed to adjust the heater circuit resistance of the balance thermoelement to a predetermined value. Refer to figure 7 below which shows the B STANDARDIZE circuit in simplified form. The circuit is essentially a bridge connected across the accurately controlled reference voltage source, zener diode CR601. The B controls are set to adjust the heater circuit resistance of the balance thermoelement TC702 equal to the Attenuator Adjust resistance. This Attenuator Adjust resistance is made up of resistors R449, R450, R451, and R452 on the schematic diagram. Standardization of this circuit is controlled by the B STANDARDIZE controls, a concentric combination consisting of switch S104 and resistor R127. Resistors R445 and R446 make up the other arms of the bridge. The switch S403 shown on the schematic is a coarse factory adjustment set to obtain the proper operating range for the front panel controls.

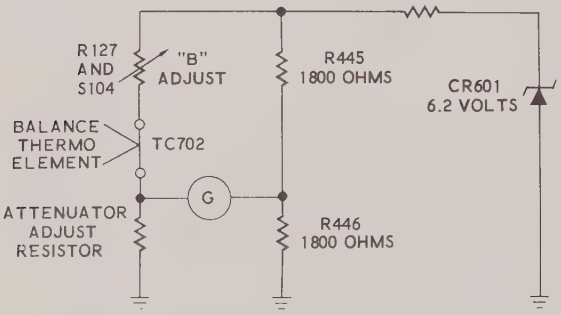


Figure 7. Simplified B Standardize Circuit

d. C STANDARDIZE Circuit. This standardize circuit is designed to set the heater circuit resistance of the input thermoelement to match the predetermined resistance to which the balance thermoelement heater circuit resistance was set in the previous calibrating step. (Refer to the simplified circuit diagram, figure 8.) The thermoelement heater circuit is connected in a bridge circuit similar to that used in the previous B standardization. The zener diode CR601 is again used as a voltage source across the bridge with R445 and R446. The balance thermoelement heater circuit and the resistance previously calibrated in the B STANDARDIZE procedure are now used in one arm of the bridge to calibrate the input thermoelement TC701 heater circuit resistance and its associated standardize resistance. C standardization is accomplished by the adjustment of the C STANDARDIZE controls made up of concentric switch S103 and resistor R115. When C

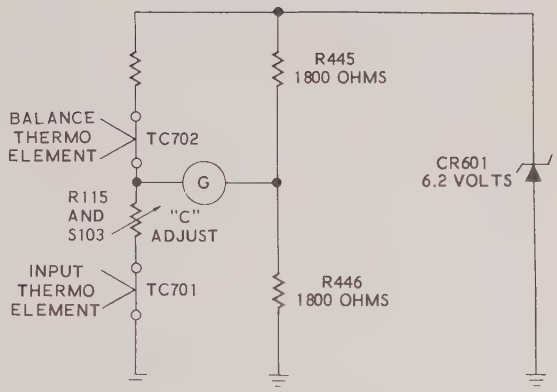


Figure 8. Simplified C Standardize Circuit

standardization is accomplished and the meter is nulled, the balance thermoelement heater circuit and the input thermoelement heater circuit will both be set to the same resistance as the Attenuator Adjust resistor. The switch S402 shown on the schematic is a coarse factory adjustment set to obtain the proper operating range for the front panel controls.

e. D STANDARDIZE Circuit. This standardization circuit is designed to adjust the differential thermoelement EMF output to zero when equal currents are flowing in their heaters. The basic differential thermoelement circuit is shown in figure 9. Notice that the two thermoelement heaters are connected in series across the zener diode controlled voltage source. This insures that the same heater current of 5 milliamperes flows through each thermoelement heater. The thermoelement outputs are connected in series with their output EMF polarities in opposition. The null detector will indicate zero when the output EMF's are balanced. The standardization circuit is shown in simplified form in figure 10. Balance is accomplished by connecting a 1 ohm resistor in the ground leg of each thermoelement output lead and passing a small correction current through one of

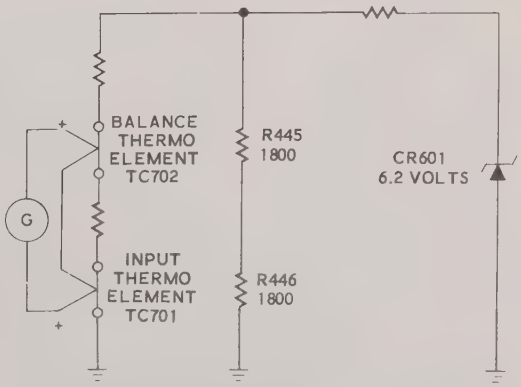


Figure 9. Thermoelement Circuit - D Standardize Position

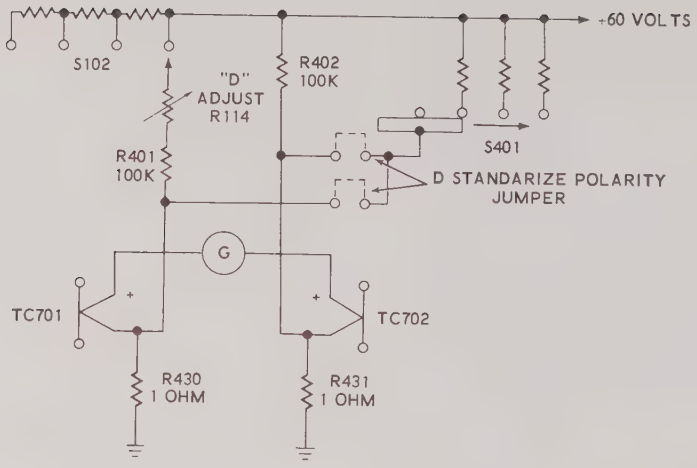


Figure 10. Simplified D Standardize Circuit

the resistors. The voltage drop thus produced will add to the output EMF of one of the thermoelements to equalize their EMF outputs. These equalizing resistors are R430 and R431. Initial adjustment of this circuit is accomplished in the factory by positioning the "D Standardize Polarity Jumper" and adjusting switch S401 to obtain the proper operating range of the front panel controls. Standardization is then controlled by the D STANDARDIZE controls, concentric controls consisting of switch S102 and resistor R114.

f. It should be noted from the above circuit descriptions that these standardization procedures are not only dependent upon one another but that it is important that they be performed in proper sequence in alphabetical order.

3.5 Reference Supply

a. General. The precision reference voltage supply acts as the constant current source required to operate the balance thermoelement. The simplified schematic of the reference source will be found in figure 11. Heart of the reference supply is the zener diode CR601. This diode is carefully selected and aged over a 90 day period to insure its long term stability. In addition to this, the zener diode is operated in a temperature controlled oven which is stabilized at approximately 70 degrees C and held to ± 0.5° C over the ambient temperature range.

b. Reference Circuit. The reference voltage circuit is operated directly from the 60 volt regulated DC supply. The stable 6.2 volts provided by the zener diode is applied across a resistance network and then across the heater circuit of the balance thermoelement. Resistors R614 through R624 are factory adjusted to provide the proper current through the balance thermoelement by proper positioning of the "Reference Current Setup Jumpers." The sensitivity test keys for 0.1% and 0.01% are designed to bypass that percentage of the total balance thermoelement heater current when depressed. A change of 0.1% or 0.01% in the reference

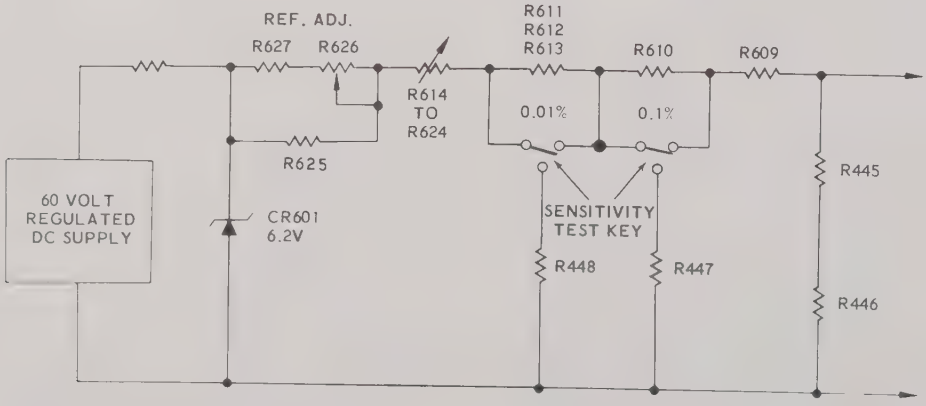


Figure 11. Reference Supply Circuit

circuit will produce a corresponding 0.1% or 0.01% deviation on the null indicator for calibration purposes.

3.6 Oven Circuits

a. General. The Model 10 contains two oven circuits used to control the temperature of critical components. One of these oven circuits controls the temperature of the reference zener diode to insure that the reference voltage does not vary with ambient temperature. The second oven circuit controls the temperature of the two thermoelements. The temperature of each oven is maintained by a proportional control circuit which senses the unbalance of a bridge, one leg of which is a thermistor.

b. Reference Oven Circuit. This oven control circuit operates from the 60 volt regulated DC supply. It consists essentially of a bridge circuit made up of resistors R601, R605, and R606 and thermistor RT601. The thermistor is located in the reference oven and senses its temperature. Variations in oven temperature are reflected as unbalance in the bridge circuit and are sensed by a differential amplifier made up of transistors Q601 and Q602. This unbalance is amplified by transistors Q603 and Q604 employed in a Darlington emitter follower circuit. The oven heater is connected in the emitter of Q604 and takes the form of two parallel resistors R607 and R608. The reference oven regulates at approximately 70 degrees C and will hold the regulated temperature within ± 0.5 degrees C over the instrument ambient temperature range. The oven requires about 10 minutes to reach its equilibrium temperature from an ambient temperature of 25 degrees C. The warm up current required in the heater circuit is 130 to 160 milliamperes and the current required to regulate when the ambient is 25 degrees C is 50 to 100 milliamperes.

c. Thermal Converter Oven Circuit. This oven circuit is also a proportional control circuit and is similar in most respects to that used on the reference oven. One difference is the use of a second thermister RT401 to sense the ambient temperature and thereby provide tighter oven temperature control over the ambient range. A second difference in this oven over the reference oven is the heater element itself. The heater for the thermal converter oven is resistance wire wound around the oven rather than the resistors as used above. The thermal converter oven requires approximately 30 minutes to reach an equilibrium temperature from an ambient temperature of 25 degrees C. The warm up current required in the heater circuit is 180 to 240 milliamperes and the current required to regulate when the ambient is 25 degrees C is 75 to 125 milliamperes after warm up.

3.7 Protective Circuits

a. General. There are two protective circuits employed in the Model 10. The first is an SCR circuit that is connected directly across the input thermoelement heater; the second is the overload relay protection circuit. These two circuits are each described below and are illustrated in figures 12 and 13.

b. SCR Protection Circuit. The SCR protection circuit consists of two silicon controlled rectifiers (CR404 and CR405) and four small diodes (CR402, CR403, CR406, and CR407) connected directly across the input thermoelement heater. See figure 12. The silicon controlled rectifiers (SCR) and diodes are arranged in two back-to-back circuits. This arrangement provides protection against overloads on both polarities of DC as well as on both half cycles of any applied AC. The SCR's act as solid state switches which are normally off and present a high impedance to any applied voltage. The diodes are connected into the gate circuit of the SCR's and are essentially connected directly across the thermoelement. The diodes also offer a high impedance to low level signals appearing across the thermoelement. When the voltage across the thermoelement increases and reaches the Fermi conduction levels of the diodes and gate circuit of the SCR's, current through the diodes increases rapidly. This current flowing through the gate circuit fires the SCR's. When the SCR is fired, it presents practically a short circuit to any applied voltage and essentially clamps the voltage across the thermoelement at 0.7 volt. The SCR's are selected to handle large amounts of current for very short periods. The high current through the SCR's will be of short duration, since the overload relay will function to open the circuit in 30 to 100 milliseconds.

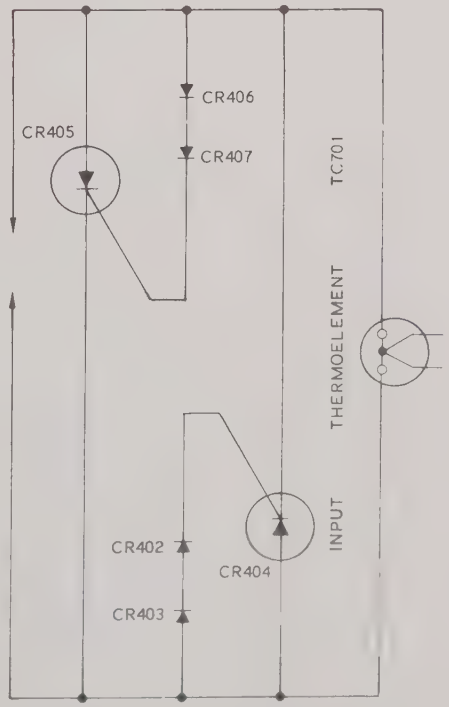


Figure 12. SCR Protection Circuit

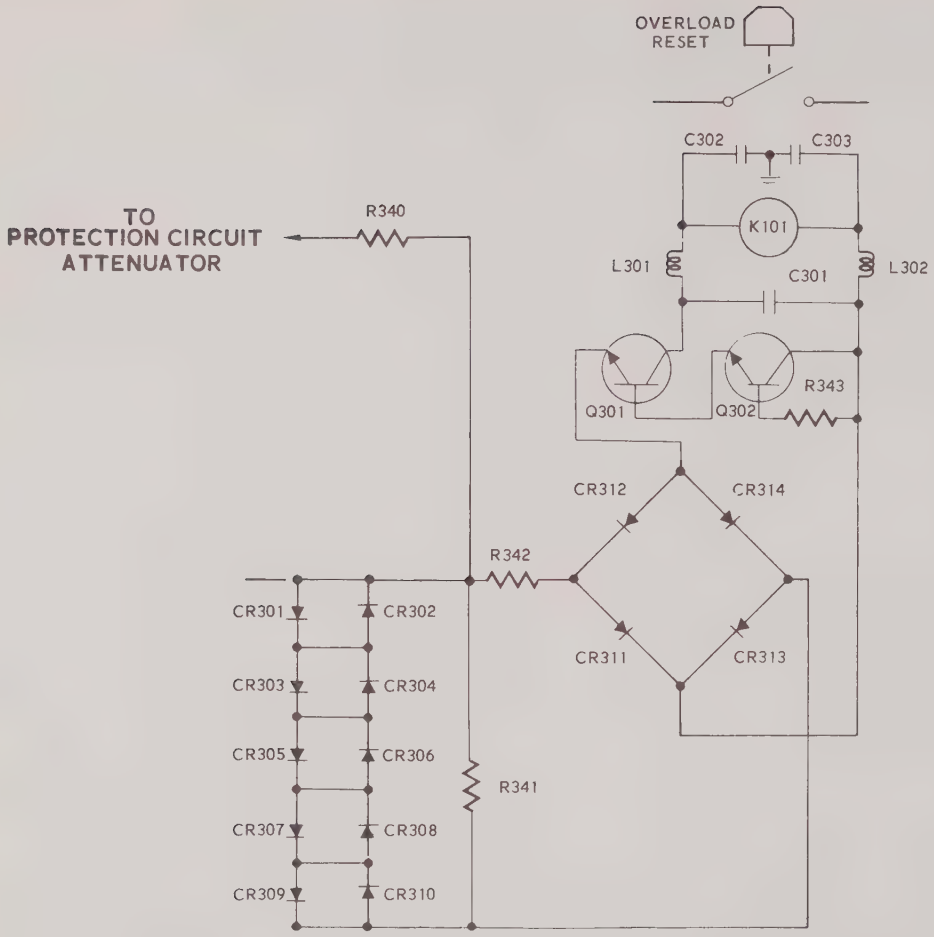


Figure 13. Overload Relay Circuit

c. Overload Relay Protection Circuit. The overload relay protection circuit senses the input voltage and opens the input circuit in the event of any long term overload, thus protecting the attenuator resistors, function switch, wiring and silicon controlled rectifiers. The input circuit is sensed by a resistive attenuator (R301 thru R339) connected across the input terminals. See figure 13. This attenuator is a part of the voltage switches and is so wired that its output voltage is approximately one volt when full scale voltage is applied to the input terminals. The output from the attenuator is connected across a full wave bridge rectifier (CR311, CR312, CR313, and CR314). A full wave bridge circuit was selected so that the protective circuit will be sensitive to both polarities of DC as well as AC overloads. Output from the bridge circuit is applied to the input of a Darlington transistor amplifier. This amplifier, in turn, controls the action of the overload relay. Use of the amplifier limits the current through the relay coil to a small value until the voltage applied to the input circuit of the Model 10 reaches 150% to 250% of the rated range voltage. When the voltage exceeds this limit, the amplifier closes the relay and the input circuit is opened (see complete schematic at the rear of the manual.) Once the overload relay has been tripped, the overload must be removed (this must be done by switching to STANDBY) and the overload relay must be reset manually by pressing the reset button on the front panel. The large capacitor (C301) across the overload relay coil permits operation of the relay circuit at all frequencies within the range of the instrument. The capacitors (C302 and C303) and the chokes (L301 and L302) act as an RF filter for the relay.

The diodes used in the bridge circuit are sensitive germanium diodes having low peak inverse voltage rating. Since the voltage across the bridge circuit under overload conditions may exceed this rating, the back-to-back circuit consisting of diodes CR301 through CR310 is connected across the bridge. These diodes are selected to begin conduction at the point where the bridge might be damaged and thus bypass any excessive overload current around the bridge circuit.

d. Summary. In the event of an overload that might damage the input thermoelement, the silicon controlled rectifiers will instantly trigger to pro-

vide a low resistance path around the thermoelement, thus protecting it from burnout. The SCR's will carry the high overload current for a period of 30 to 100 milliseconds at which time the overload relay wil operate and open the input circuit removing the overload.

WARNING

Be sure to remove the overload by turning the function switch to STANDBY position before attempting to reset the overload relay. Failure to do so may result in damage to the switches, attenuator resistors, SCR's, etc.

3.8 Null Detector

a. General. The null detector consists of a meter and two printed circuit boards. Figure 14 illustrates a block diagram of the null detector.

Input to the null detector is applied to one set of contacts on a mechanical chopper. The chopper is powered by a 94 cps multivibrator. This arrangement provides excellent line isolation. Output from the chopper is fed through an isolation transformer to the chopper amplifier. The chopper amplifier is gain stabilized with feedback and provides a sensitivity of 7 microvolts full scale. Output of the amplifier is demodulated by the second section of the chopper operating as a synchronous demodulator. The resulting DC is applied to the null detector meter.

b. Power Supply and Chopper Drive Circuit Board. Refer to the schematic diagram. Line voltage is applied to the primary of power transformer T801. The secondary voltage is rectified and regulated by transistor Q801, a series pass regulator. Output of the regulator circuit is sensed at the arm of resistor R813. Adjustments of this control sets the regulated output at +11.5 volts DC. Transistors Q804 and Q805 make up a differential amplifier that compares the output voltage to the voltage across zener diode CR803. The difference or error voltage is amplified by Q803 and Q802 and used to control the series pass regulator.

The four transistors Q806, Q807, Q808 and Q809 make up a free running multivibrator which supplies a 10 volt peak-to-peak signal to operate chopper G901, located on the amplifier board. The multivibrator operates at a frequency of 94 hertz. Frequency is adjusted by potentiometer R825. Resistor R140 is a front panel control - the "A" STANDARDIZE control, and it supplies some chopper drive signal to the amplifier. The phase of the signal is adjusted by the control as required to zero the null detector meter.

c. Amplifier Circuit Board. Refer to the schematic diagram. The input to the null detector is the difference voltage generated by the two thermoelements in the Model 10. This very small output voltage is connected to the chopper G901 and to the center tap of transformer T901. The secondary provides an AC signal to the bases of transistors Q901 and Q902. The AC signal varies in phase and magnitude with the difference voltage from the thermoelements. The outputs of transistors Q901 and Q902 are fed to a differential amplifier consisting of transistors Q903 and Q904. Output of this amplifier is connected to terminal PA and supplies an external network which controls the sensitivity of the meter. The NULL SENSITIVITY switch (S107) sets four levels of meter sensitivity when the FUNCTION switch (S101C) is in the AC or DC position. Sensitivity is set by the FUNCTION switch in the STANDBY and each of the STANDARDIZE positions.

The signal from terminal B is amplified by another differential amplifier consisting of tran-

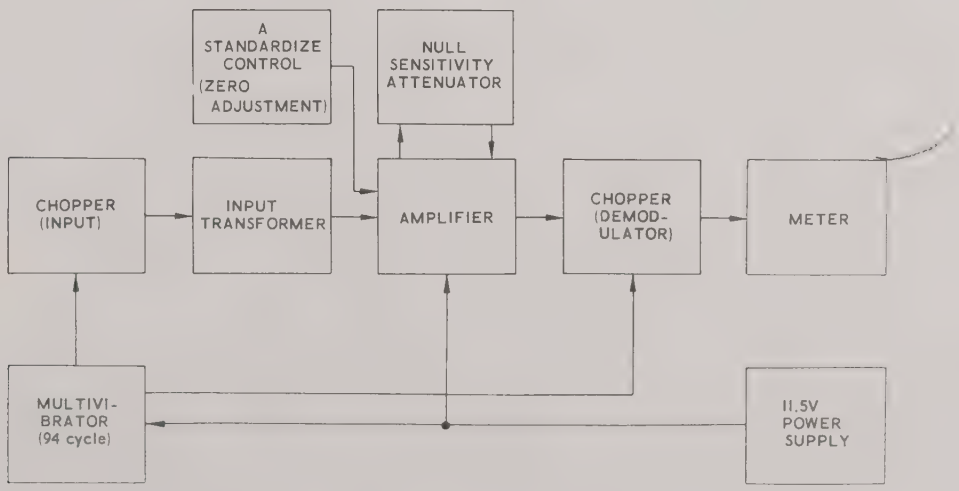


Figure 14. Null Detector Block Diagram

sistors Q905 and Q906. It is then amplified by a pair of common emitter amplifiers (Q907 and Q908). An emitter follower, transistor Q909, drives the output half of the chopper. The chopper acts as a synchronous demodulator and the resulting DC signal is filtered by C911 and C912 and supplies the meter M101. Control R926 acts as a gain control for the circuit by varying the negative feedback to Q906.

3.9 Power Supply

a. General. The power supply used on the Model 10 is a highly regulated, solid state circuit employing a controlled series regulator. Over the specified temperature range of the Model 10, this supply has excellent stability and extremely low peak-to-peak ripple. A block diagram of the basic regulator circuit is shown in figure 15. The output of the regulated supply is sampled by a voltage divider consisting of R511 and R512. This output sample is applied to a differential amplifier. The

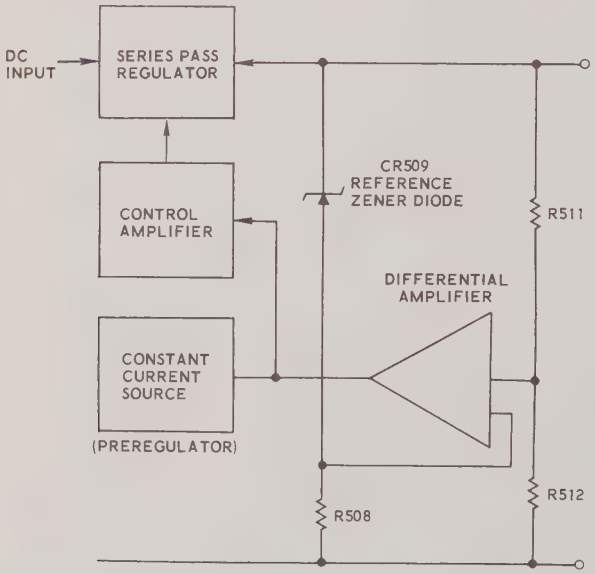


Figure 15. Power Supply Regulator Block Diagram

symmetrical arrangement of a differential amplifier tends to make it self-compensating for temperature variations. This compensating effect is further improved by connecting the differential amplifier transistors together with a common heat sink. The differential amplifier compares the output sample to the voltage across the zener reference diode. Any error or drift in the output voltage is amplified by an error amplifier, fed to a control amplifier, and used to control the action of the series regulator. The regulator, in turn, corrects the output voltage.

b. Regulator Circuit. Refer to the power supply schematic diagram at the back of the manual. The output of the power supply regulator is sensed between resistors R511 and R512 and applied to the input of the differential amplifier consisting of transistors Q504 and Q505. This output voltage is compared to the zener diode voltage across CR509. The resultant error voltage is applied to the base of an error amplifier transistor Q503. Diode CR507 maintains equal voltages across both halves of the differential amplifier and together with the resistor R506 acts as a constant voltage reference point for the emitter of Q503. The output of the control amplifier is applied to the base of transistor Q501, a driver amplifier, which controls Q101 the series pass regulator. Zener diode CR505 acts as a pre-regulator for the collector current of Q503. Transistor Q502 is connected to sense the voltage drop across resistor R505. In the event this voltage drop rises beyond normal levels due to an excessive drain of current from the power supply regulator, transistor Q502 will act to bypass some of the base current from the driver transistor Q501, cutting off the series pass regulator and limiting the excessive current drain.

c. Rectifier Circuit. The AC line voltage is applied directly to the primary of transformer T101. The secondary voltage is applied across a bridge rectifier. Rectifier output with conventional RC filtering is supplied to the regulator circuit.

SECTION 4

RECALIBRATION

4.1 Recommended Test Equipment

When performing the maintenance and calibration checks as described in the following paragraphs, the recommended test instruments, or instruments of similar quality, should be used. See Table I.

4.2 Preliminary Check

Performing the preliminary checks listed below will give a complete evaluation of instrument operation. This procedure provides a means of determining whether a servicing problem is present or if recalibration is required.

NOTE

The test equipment for each check is referenced in parentheses. When the DC Standard Measurement System and Galvamometer is referenced, it implies that the DC Source is to be monitored by the DC Standard Measurement System and adjusted to within ± 0.003% of the indicated value.

It must be realized that the error effects of the DC Accuracy, Accuracy (True 400 Hz AC/DC Difference), and the Accuracy (True Frequency Response) are accumulative and their algebraic sum under any rated conditions of voltage and frequency must not be greater than the specifications of the instrument even though their individual effects are less than the values stated in this section.

a. Mechanical Meter Zero. Check the front panel meter for proper zero with the power off and the instrument in normal operating position. Readjust by turning the screwdriver adjustment on the meter cover as required.

b. Warm-up Period. Testing for performance specifications shall be preceded by a one hour warm-up period under power. When the test instrument is coming from storage (non-operating) temperatures (-25° C. to 60° C.) an additional 1 hour of warm-up should be allowed (non-operating) in the operating ambient prior to commencement of the one hour warm-up period (under power).

c. Special Environmental Conditions. Because of the precise accuracies involved, tests to determine accuracy or stability should be conducted at constant, predetermined environmental conditions. Any other ambient conditions imposed should allow for the specified effects of temperature.

Recommended Test Ambient Conditions:

Temperature: 23° ± 1° C.
Relative Humidity: 20 to 50%
Altitude: Sea level to 6,000 feet

d. System Grounding. The test instrument and all connected test equipment should be operated off of power line grounds by the insertion of 3 wire to 2 wire power cord adaptors (isolators). With all ground posts (common) connected together, provide a single, heavy connection to ground from one point in the ground system.

NOTE

The provision of multiple ground paths or loops permits circulating currents which detract from measurement accuracy.

e. Visual Inspection. Insure all controls, terminals and indicators are free of damage or mechanical interference and all knobs and knob pointers are properly oriented and securely fastened to their respective shafts.

f. Main Attenuator Resistance Check (Ohmmeter). With the unit disconnected from the power line, disconnect the output of the main attenuator by pulling P105 free from J105. Connect one lead of an ohmmeter to the center conductor of the DC VOLTAGE INPUT connector and turn the FUNCTION switch to DC. Connect the other lead of the ohmmeter to J105. The attenuator resistance must conform to values shown below.

NOTE

An X in a voltage setting such as X.000 indicates that the particular voltage control readout window has a 10 showing.

Attenuator Reading	Resistance (approximate)
000.000	20 ohms
000.000 thru 000.00X	Step 0.2 ohms per 0.001 V. dial change
000.000 thru 000.0X0	Step 2 ohms per 0.001 V. dial change
000.000 thru 000.X00	Step 20 ohms per 0.1 V. dial change
001.000	20 ohms
001.000 thru 00X.000	Step 200 ohms per 1.0 V. dial change
000.000 thru 0X0.000	Step 2000 ohms per 10 V. dial change
000.000 thru X00.000	Step 20,000 ohms per 100 V. dial change

TABLE I

EQUIPMENT REQUIREMENTS

Item	Minimum Use Specifications	Calibration Equipment
Potentiometer	± .01%, 0 to 2.0 volts (NBS Traceable Calibration)	L & N Model 7556
Standard Cell Bank	Saturated standard cells (NBS Traceable Calibration)	Guildline Std. Cell Enclosure Type 9152
Galvanometer (with photo-amplifier)	At 100 ohms impedance - .5 microvolt/cm	Guildline Model 9460/9461A
Ohmmeter	200-220K ohms, accuracy of reading ± 10%	H.P. Model 410C
RF Voltmeter	0-5 volts, 1MHz, accuracy ± 5%, F.S., 0-400 volts, 300 kHz	H.P. Model 410C
DC Voltmeter	0-1100 volts, ± 2% F.S.	H.P. Model 410C
DC Source	0-1000 volts, Variable Stability ± .001% Hr. Accuracy ± .003% Resolution ± .01%	Fluke Model 332A
AC Source (High RF)	0-2.5 volts 1 MHz 0-250 volts 300 kHz 0-375 volts 100 kHz	Holt Model 335 RF Signal Generator Holt Model 355 RF Tuning Unit
Stopwatch	1/100 min./div. resolution	
AC Source (Low Audio)	1-1000 volts, 400 Hz .01% Stability	Holt Model 324, Audio Voltage Standard
AC Source (High Audio)	1-1110 volts, 400 Hz - 20 kHz., .01% Stability	Holt Model 324, Audio Voltage Standard
AC Source (Low RF)	1-1110 volts, 20 kHz - 100 kHz, .01% Stability	Holt Model 356
DC Standard Measurement System	Voltbox, 1500 volts, 20 ppm Potentiometer, 15 ppm Standard Cell Bank (see above)	Guildline Model 9700-A L & N Model 7556
AC Voltage Standards (HFTC)	1 volt	NBS Type Thermal Voltage Converter
	50 volts	NBS Type Thermal Voltage Converter
	100 volts	NBS Type Thermal Voltage Converter
	200 volts	NBS Type Thermal Voltage Converter
	1000 volts (All NBS Traceable Calibration)	Holt Thermal Voltage Converter P/N 90080/90081
HFTC Readout Device		
Counter	90-100 Hz, 0.1% General Laboratory Type	
Oscilloscope	General Laboratory Type	

g. Relay Protection Circuit Attenuator Check (Ohmmeter). Leave the line cord and main attenuator disconnected as in step h. Check the resistance from the center pin of the DC VOLTAGE INPUT connector to the input terminal of the Relay Protection Circuit Board as shown in figure 25 with the FUNCTION switch in the DC position.

The resistances must conform to the values below:

Attenuator Reading	Resistance (approximate)
000.000	0 ohms
001.000 thru 001.X00	Step 100 ohms per 0.1 V. dial change
001.00 0 ohms	0 ohms
001.000 thru 00X.000	Step 1000 ohms per 1.0 V. dial change
000.000 thru 0X0.000	Step 10,000 ohms per 10 V. dial change
000.000 thru X00.000	Step 100,000 ohms per 100 V. dial change

Reconnect J105 to P105.

h. SCR Protection Circuit Check (DC Voltmeter, DC Source). Remove the thermoelement jumper shown in figure 27 and solder in a 91 ohm resistor as shown in the same figure. Place the VTVM across the 91 ohm resistor. Open the overload relay K101 and connect a jumper across its contacts. Set the attenuator to 001.000 volts and the FUNCTION switch to DC. Apply 1 VDC to the DC VOLTAGE INPUT. Increase this voltage in 0.1 V. steps until the VTVM reading reaches a maximum and then drops back. This maximum must be between 0.8 VDC and 1.4 VDC. It should drop back to approximately 0.7 VDC. It is necessary to decrease the input voltage to zero before repeating the above procedure. Reverse the input polarity and repeat.

i. Relay Protection Circuit Check (DC Source). Remove the input voltage, remove the jumper across the overload relay and reset the relay. Reapply the input DC voltage and increase it until the overload relay trips when the FUNCTION switch is switched from STANDBY to DC. The relay must trip between 1.5 VDC and 2.5 VDC. Reverse this input polarity and repeat. Remove the input voltage, the VTVM, and the 91 ohm resistor. Replace the thermoelement jumper.

j. Test Instrument Connections. The line power cord is connected to a receptacle of rated line voltage and frequency.

k. Turn-on Procedure. After compliance with the proper warm-up procedures and under the special environmental conditions, all tests, unless otherwise indicated are conducted with the POWER switch set at the ON position, OVERLOAD RESET depressed, and both SENSITIVITY TEST KEYS up (not depressed).

The following STANDARDIZE procedure must be performed prior to all tests.

Place the FUNCTION switch in the "A" position and adjust the "A" STANDARDIZE control (indicated by Light) for a zero on the null detector meter. Place the FUNCTION switch in the "B" position and adjust the "B" STANDARDIZE controls for a zero on the null detector meter. Repeat this procedure for the "C" and "D" positions of the FUNCTION switch respectively. Allow time in position "D" for stabilization of reading prior to adjustment. Return the FUNCTION switch to the STANDBY position when accomplished.

NOTE

Whenever the standardization procedure is accomplished, it must be in alphabetical order and all four positions should be checked and adjusted if necessary. Never reverse the order and never adjust one without checking all four positions.

l. Null Detector Sensitivity (DC Source). Connect the DC source to the DC VOLTAGE INPUT terminals, set the VOLTAGE selector switches for 010.000 volts, and set the DC source for 010.000 volts output. Set the FUNCTION switch to the DC position and increase sensitivity by adjusting the NULL SENSITIVITY control from SEARCH to COARSE to MEDIUM to FINE. Progression to the next highest sensitivity setting must be preceded by a null indication in the lower position. Adjustment of the VOLTAGE selector controls (if necessary) to achieve a null is permitted.

When in the FINE position with the NULL SENSITIVITY control, raise the applied voltage to 010.001 volts. Note the displacement in the null indication. Return the applied voltage to 010.000 and again note the displacement in the null indication.

A displacement of less than eight minor divisions or more than twelve minor divisions indicates a need for recalibration of the null detector.

m. Sensitivity Test Keys (DC Source). Apply 010.010 volts to the DC VOLTAGE INPUT terminals (FUNCTION switch at DC) and adjust the VOLTAGE selector switches (with the NULL SENSITIVITY switch in FINE), for an indicated null at the center of the null meter scale. Depress the .1% SENSITIVITY TEST key. (Deflection will be to the right.) Simultaneously, change the applied voltage to 010.000 (keeping .1% SENSITIVITY key depressed). The meter indication should return to within ± 20 minor divisions of the null indication obtained before the .1% SENSITIVITY TEST key was depressed.

Apply 010.001 volts to the DC VOLTAGE INPUT

terminals and adjust the VOLTAGE selector switches (with the NULL SENSITIVITY switch in FINE) for an indicated null. Depress the .01% SENSITIVITY TEST key. Upon completion of the meter travel, change the applied voltage to 010.000 (keeping the .01% SENSITIVITY TEST key depressed). The null should return to within ± 2 minor divisions of the null indication obtained before the .01% SENSITIVITY TEST key was depressed.

n. Stability, Short Term (DC Source, Stopwatch, DC Standard Measurement System, Galvanometer).

NOTE

Cover must be in place on the instrument for a period in excess of 15 minutes before beginning this test.

(1) Apply an input signal of 010.000 volts from the DC source to the DC VOLTAGE INPUT terminal. Switch the FUNCTION switch to DC and achieve a null with the NULL SENSITIVITY switch in the FINE position. Maintain the null for a period of 2 minutes, readjusting input level if necessary. Place the FUNCTION switch in STANDBY. Allow an idle 5 minute period without readjustment of the VOLTAGE selector controls.

(2) Start a stopwatch at the same instant as the FUNCTION switch is returned to DC. Switch the NULL SENSITIVITY control from SEARCH to COARSE to MEDIUM to FINE. Record the null indication at 90 seconds (1-1/2-minutes), 120 seconds (2 minutes), and at each minute thereafter for 20 minutes. Adjust the DC source as necessary to hold its output constant as measured with the DC Standard Measurement System and Galvanometer to a stability of ± 10 ppm.

(3) At 90 seconds after the reapplication of signal, the indication must be within ± .01% of the 2 minute indication. Readings at succeeding one minute intervals out to 20 minutes must remain within ± .005% of the 2 minute indication.

o. DC Reversal Error (DC Source, DC Standard Measurement System, Galvanometer). Connect the DC VOLTAGE INPUT terminals to the DC source. Set the input voltage at 10.000 volts and ungrounded.

Set the FUNCTION switch to DC and the NULL SENSITIVITY switch to FINE, set the VOLTAGE selector switches so that a null is achieved. Reverse the leads at the DC source and observe the new meter indication without readjustment of the voltage controls. Repeat the above at 1.000 VDC. The difference between the first and second meter indications is DC reversal. (Divide DC reversal by two for DC reversal error.) DC reversal error must be less than ± 0.001% at both 1.000 VDC and 10.000 VDC.

TEST VOLTAGES

1.000	1.000	1.000		1.000	1.000
1.001	1.010	1.100	1.000	10.000	100.000
1.002	1.020	1.200	2.000	20.000	200.000
1.003	1.030	1.300	3.000	30.000	300.000
1.004	1.040	1.400	4.000	40.000	400.000
1.005	1.050	1.500	5.000	50.000	500.000
1.006	1.060	1.600	6.000	60.000	600.000
1.007	1.070	1.700	7.000	70.000	700.000
1.008	1.080	1.800	8.000	80.000	800.000
1.009	1.090	1.900	9.000	90.000	900.000
1.00X	1.0X0	1.X00	X.000	X0.000	X00.000

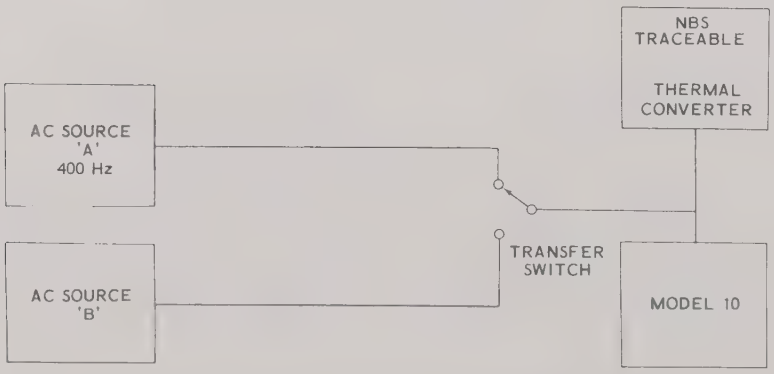


Figure 16. Frequency Response Calibration Set-up

p. DC Accuracy (DC Source, DC Standard Measurement System, Galvanometer). Connect the DC source to the DC INPUT terminals. Set its output at the voltages indicated in the table on the previous page as determined by the DC standard measurement system.

Set the FUNCTION switch at DC and the VOLTAGE selector switches at a voltage setting corresponding to that to be checked. Increase the NULL SENSITIVITY control from SEARCH to COARSE to MEDIUM to FINE.

Note any difference between the meter indications and true null (zero) in percent. Any difference in excess of .01% plus 25 microvolts (referred to the input voltage) indicates a need for recalibration.

The 1.000 V. calibration appears in each of the columns below to provide a means of signaling the operator of any standardization drift that may take place during the measurements. This reading should repeat to ± 15 ppm. Slow drifts can be corrected by restandardizing.

q. Accuracies (Frequency Response) [(AC Source (Low Audio), AC Source (High Audio), AC Source (Low RF), AC Source (High RF), AC Voltage Standards (HFTC), HFTC Readout Device)]. Connect source A (as indicated on the diagram, figure 16) and source B so that transfer between the two sources can be rapidly and easily effected. The output of the transfer assembly is connected to both the NBS Traceable Standard and the AC INPUT terminal of the Model 10.

Standardize the Model 10. Establish the amplitude of source A (400 Hz) to give a null on the Model 10 with the FUNCTION switch in AC, NULL SENSITIVITY at FINE and VOLTAGE selector controls set as indicated in Table III. Balance the NBS Traceable Standard (Thermal Converter) for a null at this level also. Transfer to source B and adjust its amplitude for a null indication on the Model 10. Record the deviation from null (apparent frequency response error) observed on the NBS Traceable Standard instrument. Reverse transfer to source A, adjust its amplitude for a null indication on the Model 10 and record the deviation from null on the standard instrument (drift). Compute the raw, uncorrected frequency response error by multiplying the sensitivity factor (k) of the standard instrument by the difference between the apparent frequency response error and half of the drift error. The result will yield true frequency response error if the known error in the standard instrument is applied as a correction factor.

For best accuracy, follow the preceding procedure three or four times and average the results. This is especially effective when the measurement is complicated by poor sensitivity or excessive drift in the standard instrument.

r. Accuracies (AC/DC Difference) [(DC Source (Low Audio), AC Voltage Standards (HFTC), HFTC Readout Device)]. Insert a reversing switch capable of reversing the DC source polarity. Use a transfer circuit to switch between the reversible DC voltage source and the 400 Hz AC source. The output of the reversal switch is connected to both the Model 10 and the NBS Traceable AC Standard (Thermal Converter). See block diagram (figure 17.

After standardizing the Model 10, connect the AC source (via the transfer assembly) to the AC INPUT terminal and set the FUNCTION switch to the AC position and the NULL SENSITIVITY switch

TABLE II ACCURACIES (TRUE AC/DC DIFFERENCE)

SOURCE	AC SOURCE FREQUENCY	STANDARD INSTRUMENT	MODEL 10 VOLTAGE SETTING	MAX. ALLOWABLE AC/DC DIFF. ERROR
AC Source (2.8)	400 Hz	10 volts HFTC	010.000	± 0.015%

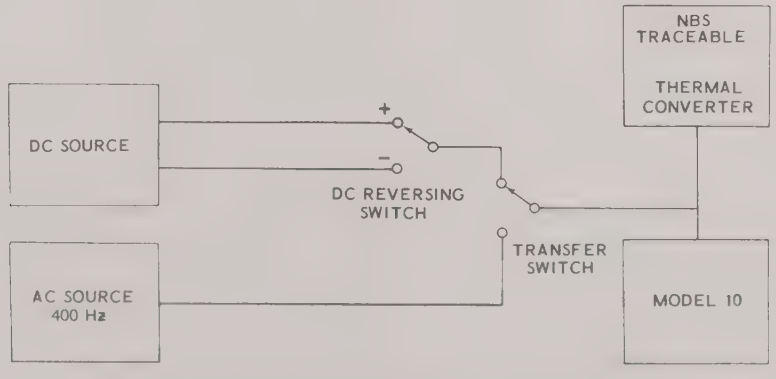


Figure 17. 400 Hz AC/DC Difference Calibration Set-up

TABLE III

ACCURACY - FREQUENCY RESPONSE

Source A	'A' Setting	Source B	'B' Setting	Standard	Model 10 Voltage Setting	Limit of Error (%)
AC Source (Low Audio)	400 Hz	AC Source (High Audio)	1 kHz	1000 Volt (HFTC)	XXX.000 Volts	± .015%
AC Source (Low Audio)	400 Hz	AC Source (High Audio)	10 kHz	1000 Volt (HFTC)	6XX.000 Volts	± .015%
AC Source (Low Audio)	400 Hz	AC Source (High Audio)	10 kHz	1000 Volts (HFTC)	XXX.000 Volts	± .020%
AC Source (Low Audio)	400 Hz	AC Source (High Audio)	20 kHz	1000 Volt (HFTC)	XXX.000 Volts	± .020%
AC Source (Low Audio)	400 Hz	AC Source (Low RF)	30 kHz	1000 Volt (HFTC)	6X0.000 Volts	± .040%
AC Source (Low Audio)	400 Hz	AC Source (Low RF)	30 kHz	1000 Volt (HFTC)	XXX.000 Volts	± .040%
AC Source (Low Audio)	400 Hz	AC Source (Low RF)	50 kHz	1000 Volt (HFTC)	6X0.000 Volts	± .080%
AC Source (Low Audio)	400 Hz	AC Source (Low RF)	50 kHz	1000 Volt (HFTC)	XXX.000 Volts	± .100%
AC Source (Low Audio)	400 Hz	AC Source (Low RF)	100 kHz	200 Volt (HFTC)	1X0.000 Volts	± .100%
AC Source (Low Audio)	400 Hz	AC Source (Low RF)	100 kHz	1000 Volt (HFTC)	XXX.000 Volts	± .450%
AC Source (Low Audio)	400 Hz	AC Source (High RF)	300 kHz	100 Volt (HFTC)	X0.000	± .95%
AC Source (Low Audio)	400 Hz	AC Source (High RF)	1 mHz	1 Volt (HFTC)	1.000	± .450%

to FINE. With the Model 10 VOLTAGE controls set as indicated in Table II, adjust the output amplitude of the AC source for a null indication on the Model 10. Balance the NBS Traceable Standard for a null at this level also. Transfer to + DC and adjust the DC source for a null on the Model 10. Record the deviation (+ DC) from null indicated on the standard instrument. Reverse the polarity of the DC and again record the deviation (- DC) from null on the standard instrument. Transfer back to the AC source, readjust its output amplitude for a null on the Model 10 and read the drift (deviation from null on the standard instrument). Repeat this entire procedure three or four times and average the results.

$$\text{AC/DC Diff(Apparent)} \left[\begin{pmatrix} \text{Average} \\ \text{DC + \& -} \\ \text{Indication} \end{pmatrix} - \begin{pmatrix} \text{Average} \\ \text{AC} \\ \text{Indication} \end{pmatrix} \right] \text{X K}$$

Where K = sensitivity factor of the standard instrument

$$\text{AC/DC Diff(True)} = \text{AC/DC Diff(Apparent)} - \text{F}$$

Where F = 400 Hz AC/DC correction factor for the standard instrument

4.3 Calibration Procedures

This section contains those adjustments that can be made to the instrument if it is found to require calibration after performing the tests described in paragraph 4.2. Any failure to meet specifications which cannot be corrected by these adjustments are covered in Servicing, Section 5.

a. Relay Adjustments. Cleaning the surface area where the movable contact rests against the relay frame with freon and a pipe cleaner will many times restore proper operation. If the overload protection relay requires adjusting, there are two adjustments possible. The first is located at the side of the overload relay and consists of a rotating permanent magnet in a holder. The second is a spring adjustment near the rear of the relay. Both adjustments are normally sealed to prevent slippage. If changes are made to either adjustment, they should be made in very small increments and the results checked each time as described in paragraph 4.2. The adjustments are critical. Seal the adjustments when changes are completed.

b. Null Detector Adjustments. Calibration of the null detector will be required only at infrequent intervals. If excessive fluctuations are noted on the null detector meter, if readings do not repeat or if the null detector sensitivity is not correct, check the null detector calibration procedures in the order given below. (Excessive fluctuation of the meter is defined as more than ± 1-1/2 minor divisions peak-to-peak.) Location of controls and terminals on the null detector circuit boards are illustrated in figures 32 through 35.

(1) Voltage (DC Voltmeter). Connect a DC voltmeter between terminals 11 and 12 on the null detector board. (Terminal 11 common.) Adjust the VOLTAGE control for a reading of 11.5 volts (± 0.1 volt).

(2) Frequency Counter. Connect a frequency counter to terminal 9 and chassis (chassis common) on the null detector board. Adjust the FREQUENCY control for 94 cps (± 1 cycle).

(3) Gain (DC Source). Connect a DC source to the input terminals of the Model 10. Adjust the source to deliver 10 volts. Null the Model 10. Change the DC source voltage by .005 volts. The meter should move full scale (± 10 minor divisions). If a full scale movement does not occur, adjust the GAIN control to give a full scale deflection.

(4) Feedback. The FEEDBACK control is a factory adjustment and must not be readjusted in the field.

c. DC Reversal Adjustment. The DC reversal error can be reduced by adjustment of R415 and checking per paragraph 4.2 o. The reversal error should be adjusted so that both the 1.000 VDC and 10.000 VDC reversal error are below ± 0.001%.

d. DC Recalibration (DC Source, DC Standard Measurement System, Galvanometer).

(1) Standardize in all positions.

(2) Apply 1.000 VDC ± 10 ppm to the DC INPUT terminals with the VOLTAGE controls set at 1.000 volt.

(3) Place the FUNCTION switch on DC and adjust the C STANDARDIZE controls to give a meter zero on FINE sensitivity.

(4) Place the FUNCTION switch on C and adjust the B STANDARDIZE controls to give a meter zero on FINE sensitivity.

(5) Check standardization in A and D positions only. Readjust if necessary.

(6) Repeat 3, 4, and 5 until no further adjustments are required.

(7) Apply 10.000 VDC ± 10 ppm with VOLTAGE controls set at 10.000 volts.

(8) Check standardization in A and D positions only. Readjust if necessary.

(9) Adjust the Reference Adjust potentiometer (R626) until a zero is obtained on FINE sensitivity with the FUNCTION switch on DC.

(10) Repeat steps 2 through 9 until no further adjustments are required.

(11) Apply 10.000 VDC ± 10 ppm with 10.000 volts set on the VOLTAGE controls (meter should be zero on FINE).

(12) Set the FUNCTION switch to position B. Adjust the Attenuator Adjust potentiometer (R451) until a zero is obtained on FINE sensitivity.

(13) Set the FUNCTION switch to DC. Adjust the Reference Adjust potentiometer (R626) until the meter reads zero on FINE sensitivity.

(14) Standardize in all positions and read out directly 1.000 VDC and 10.000 VDC within ± 0.002%.

e. Frequency Response. There should be no recompensation necessary for the attenuator unless a precision resistor has been replaced in the 100 volt decade of the main attenuator. If recompensation is necessary, contact Holt Instrument Laboratories.

f. Any abnormal operation of the instrument which cannot be corrected by the above requires servicing.

SECTION 5

SERVICING

5.1 Voltage Measurements

As a convenience for maintenance personnel, all the information required to troubleshoot the Model 10 is supplied on the schematic diagrams. This eliminates the tiresome paging required when voltage charts are used. Waveforms, when required, will also be found on the schematics.

5.2 Conditions for Voltage Measurement

The voltage measurements and the waveforms are all taken with the equipment operating under the conditions specified on the schematic diagram.

5.3 DC Voltage Measurements

All DC voltage measurements are printed in blue on the schematics. Readings are taken with a VTVM having an input resistance of 11 megohms. Readings are taken with reference to common. Values shown are ± 20% unless otherwise specified on the schematic.

5.4 AC Measurements and Waveforms

All AC measurements are printed in red on the schematics. Readings are all peak-to-peak values measured with a 10 megohm oscilloscope probe. All readings are taken with reference to common. Values shown are ± 10% unless otherwise specified on the schematic.

5.5 Component Locations

Components are labeled uniformly on schematics, parts lists, and illustrations. Location of a part can be determined by referring to the parts list. The number of the illustration showing the desired part is listed in the right hand column.

5.6 Servicing Precautions

There are a number of precautions that must be observed when servicing the Model 10. They must not be violated or permanent damage to the instrument may result.

a. Never remove any transistor or plug-in board with power applied to the instrument.

b. Never substitute component types unless authorized by Holt Instrument Laboratories.

c. Be sure to install transistors properly in their sockets. Power transistors must be securely tightened down on heat sinks.

d. Do not use a solder gun which can damage the printed circuit boards or solid state devices because of excessive heat.

e. Do not attempt to use an ohmmeter to measure the heater resistance of the thermoelements. They will be damaged by the application of more than 0.5 volts or 5 ma.

f. Low thermal soldering should be done only by qualified personnel in a well ventilated area. After repair, the joint must be identified by green paint.

g. A lead seal has been placed on the Thermal Converter Oven block to discourage field servicing of this assembly. In the event of a malfunction of a thermoelement, a replacement block assembly is available to replace this unit. If the unit is replaced, the affect of the replacement unit upon the frequency response of the instrument must be investigated. Since the thermoelements used in the Model 10 are matched sets with excellent temperature tracking and wide frequency response, Holt cannot guarantee the instrument null stability and frequency response after the seal has been broken.

5.7 Service Procedures

A standard procedure for servicing is recommended. Follow the sequence recommended below to properly maintain the Model 10. In the event of a suspected malfunction of the equipment:

a. Check front panel controls and external power supply to insure that the malfunction is within the instrument.

b. Perform the preliminary checks as detailed in paragraph 4.2 to determine if recalibration is required or if a servicing problem is present.

c. Recalibrate according to paragraph 4.3 if required.

d. If a service problem is indicated in the preliminary checks, the checking procedure should give an indication of where the trouble may be located.

e. Refer to the proper schematics, parts location illustration and the theory of operation for the section to be tested. These sections should give all required troubleshooting information.

f. In the event of difficulties in maintenance or calibration beyond the limitations of the servicing agency, contact Holt Instrument Laboratories for instructions.

SECTION 6

LIST OF REPLACEABLE PARTS

6.1 Parts Numbers

Parts in the Model 10 are labeled according to the following system:

PARTS LOCATION	SERIES NUMBER
Chassis	100
Main Attenuator	200
Relay Protection Circuit	300
Main Circuit Board	400
+ 60 VDC Power Supply Board	500
Reference Oven Board	600
Thermal Converter Oven Board	700
Null Detector Power Supply Board	800
Null Detector Amplifier Board	900

The following subassemblies are available for direct replacement and include the referenced parts:

SUBASSEMBLIES

Holt Assembly Number	Description	Parts Included in Assembly
84250	0.001 V. Decade Board Assembly	R252 thru R267
84251-1	0.1 V. Decade Board Assembly	R232 thru R241
84251-2	0.01 V. Decade Board Assembly	R242 thru R251
84252	Relay Protection Circuit Board Assembly	C301 thru C303 CR301 thru CR314 L301 thru L302 Q301 thru Q302 R340 thru R343
84253	Thermal Converter Oven Board Assembly	Q701 thru Q703 R701 thru R707 RT701 TC701 thru TC702
84254	+ 60 VDC Power Supply Board Assembly	C501 thru C505 CR501 thru CR511 Q501 thru Q505 R501 thru R513
84255	Reference Oven Board Assembly	CR601 Q601 thru Q604 R601 thru R629 RT601
84258	D Standardization Resistors Board Assembly	R103 thru R113

SUBASSEMBLIES (Continued)

Holt Assembly Number	Description	Parts Included in Assembly
84260	B and C Standardization Resistors Board Assembly	R116 thru R138
84262	Main Circuit Board Assembly	C401 thru C404 CR401 thru CR407 K401 Q401 R401 thru R453 S401 thru S403
84380	S201 Switch Assembly	R201 thru R209 R301 thru R310 S201
84381	S202 Switch Assembly	R211 thru R220 R311 thru R320 S202
84382	S203 Switch Assembly	R223 thru R231 R321 thru R329 S203
84383	Null Detector Amplifier Board Assembly	C901 thru C913 G901 Q901 thru Q909 R901 thru R929 T901
900-033C	Null Detector Power Supply Board Assembly	C801 thru C808 CR801 thru CR803 Q801 thru Q809 R801 thru R827 T801

6.2 Parts Description

A complete description and the Holt part number is supplied for each replaceable part. When ordering parts, give the complete description, the Holt part number, the reference number, the model number, and the serial number of the equipment. Holt Part Numbers that begin with the number 5XXXX are manufactured or modified by Holt and must be purchased from Holt.

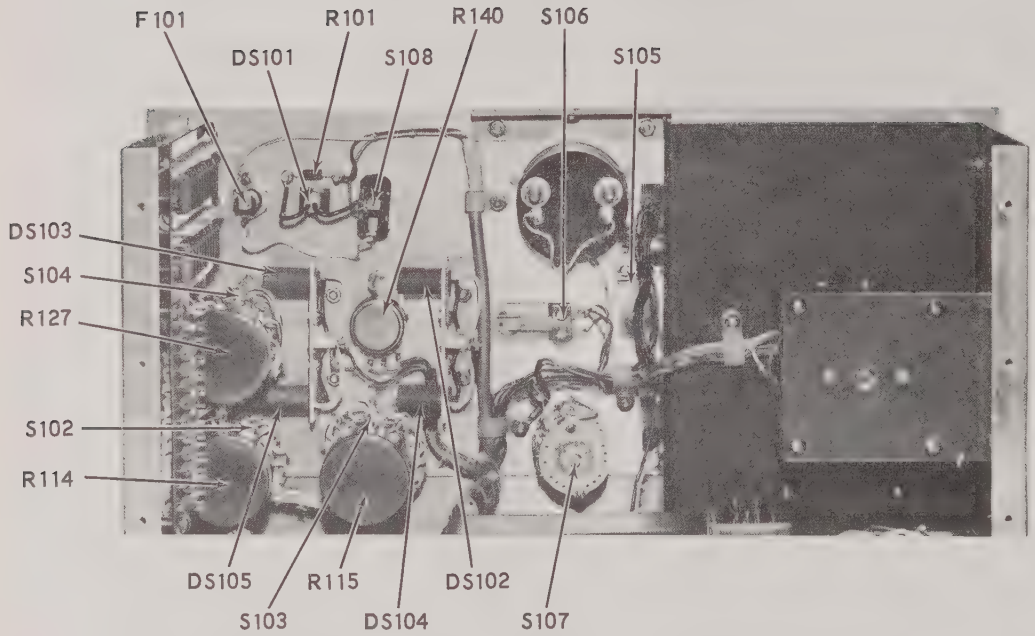


Figure 18. Front Panel Detail No. 1

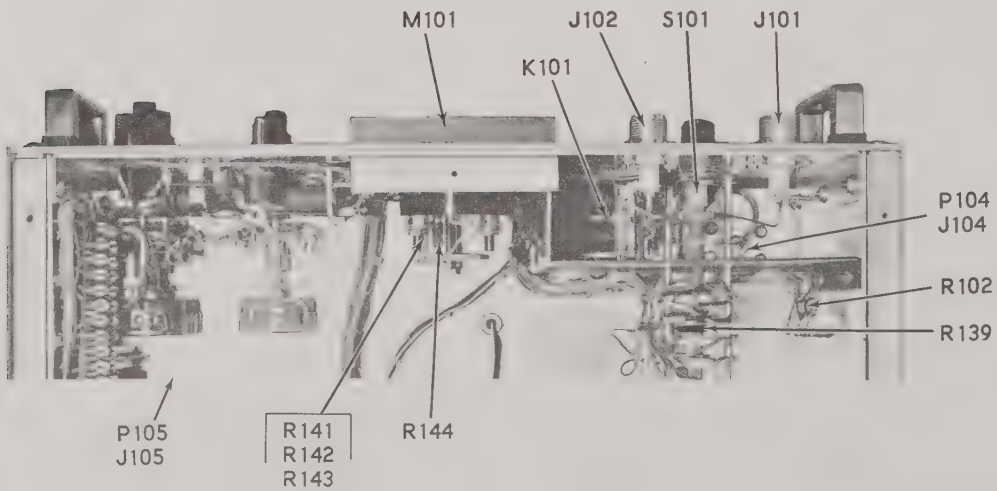


Figure 19. Front Panel Detail No. 2

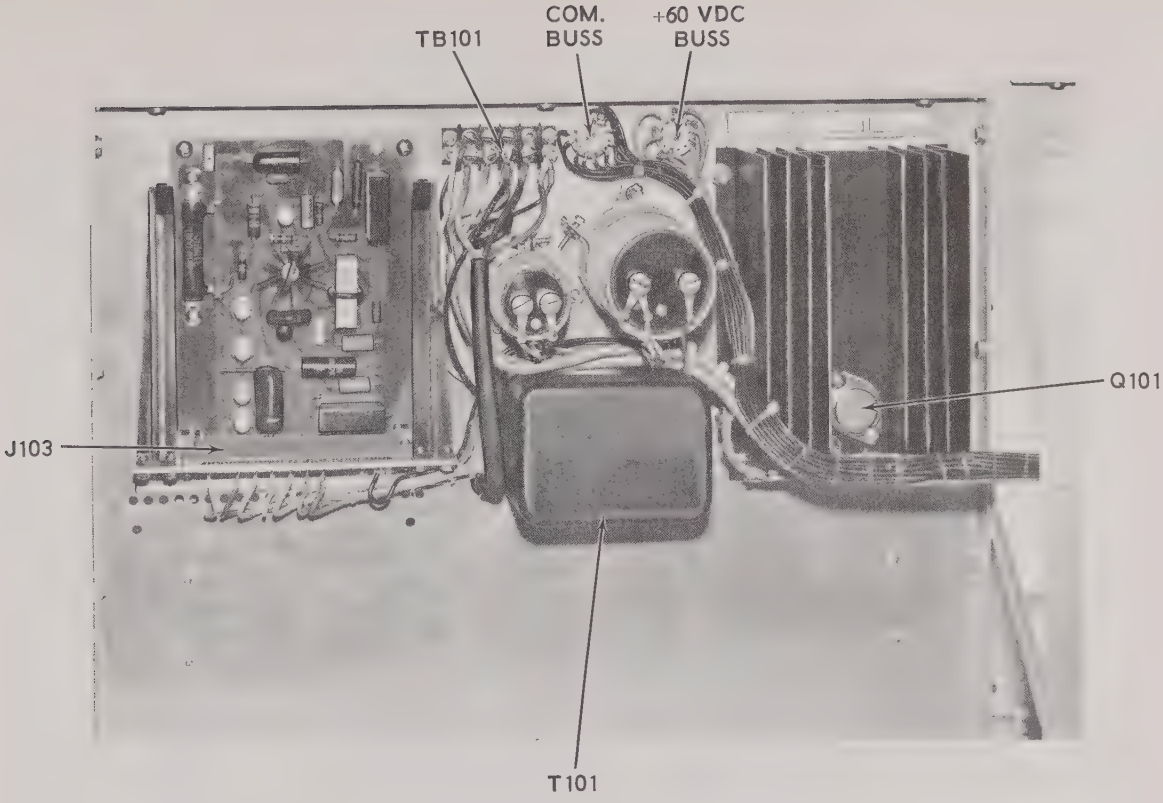


Figure 20. Rear Panel Detail No. 1

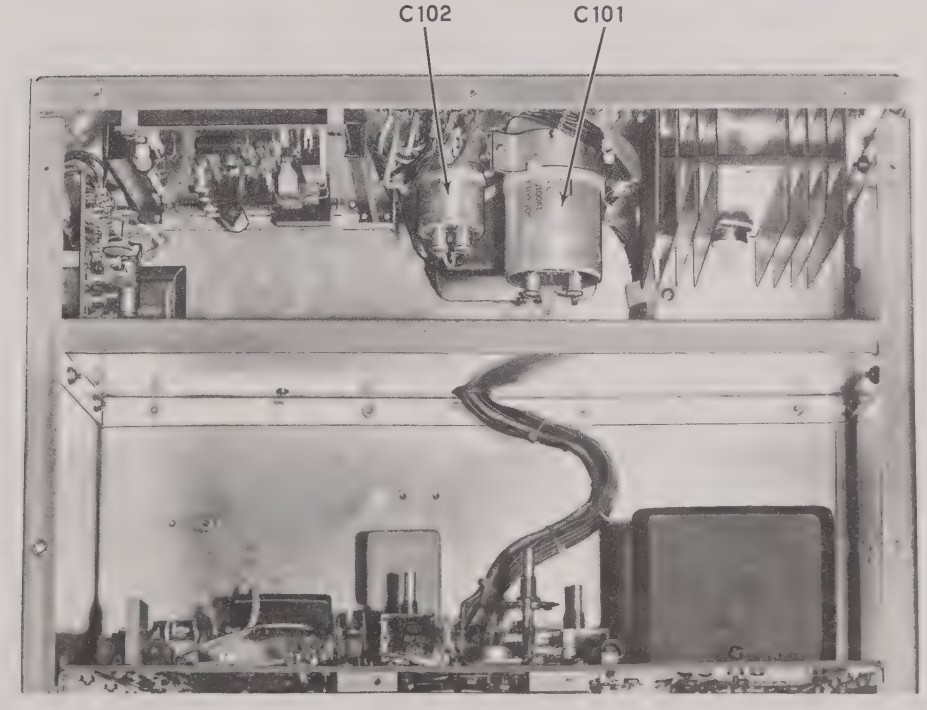


Figure 21. Rear Panel Detail No. 2

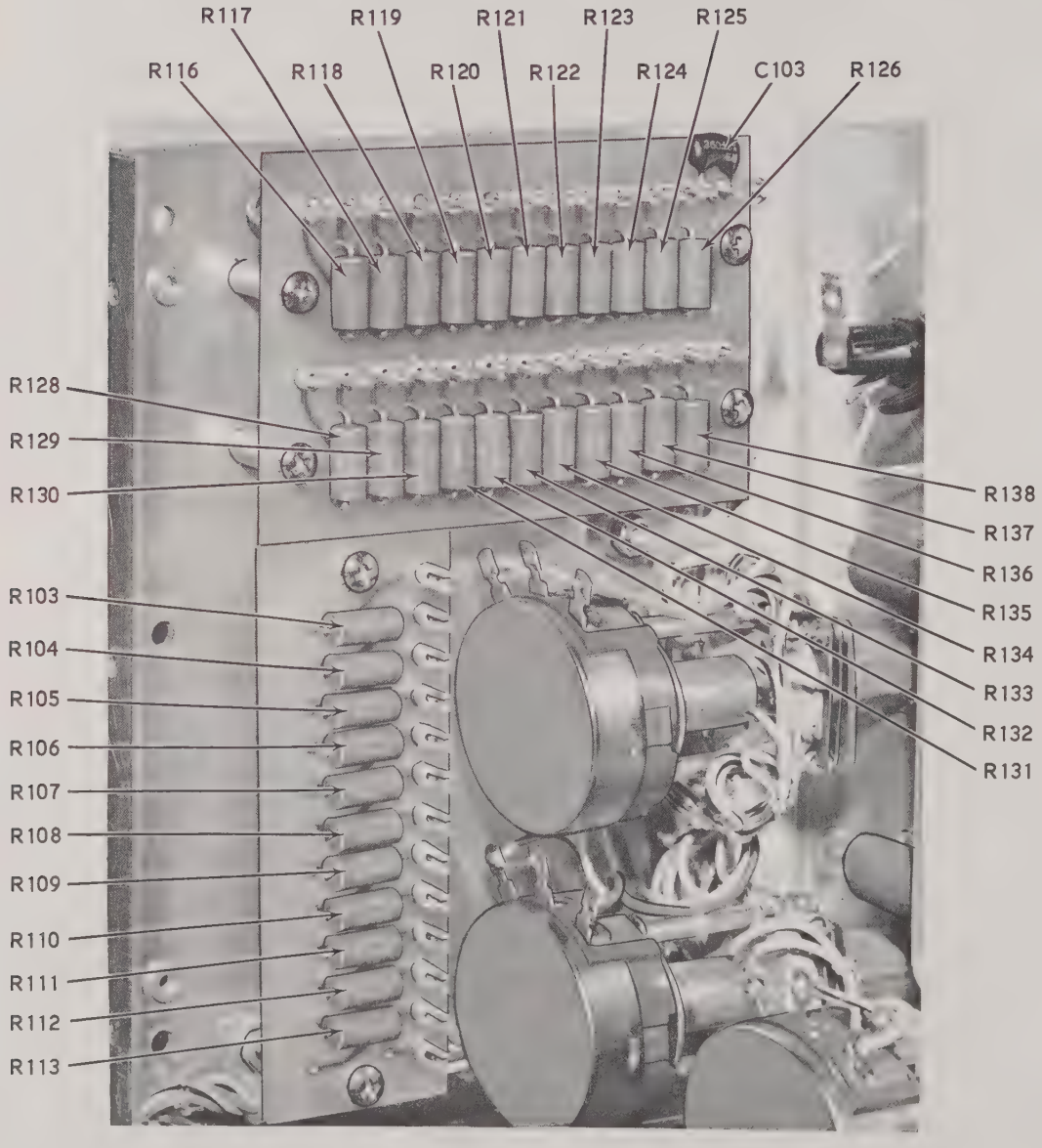


Figure 22. Right Panel Detail

LIST OF REPLACEABLE PARTS

Circuit Symbol	Description	Holt Part No.	Original Manufacturer	Original Manufacturer's Catalog No.	Figure
C101	Capacitor, Electrolytic, 1650 microfarads, 100 Volts, -10%, +75%	0905-085	Mallory	CG1651U100K1	21
C102	Capacitor, Electrolytic, 400 microfarads, 100 Volts, -10%, +50%	0905-082	Mallory	CG42U100A1	21
C103 *	Capacitor, Mica, 500 Volts, 360 pf, ± 5%	0907-065	Arco-El	DM15-361J	22
DS101	Lamp, Neon, Red, 115 Volt	0502-008	Industrial Devices	2100A1	18
DS102	Incandescent, 28 Volt, 40 MA	0501-016	Chicago Mini. Lamp	1819	18
DS103	Incandescent, 28 Volt, 40 MA	0501-016	Chicago Mini. Lamp	1819	18
DS104	Incandescent, 28 Volt, 40 MA	0501-016	Chicago Mini. Lamp	1819	18
DS105	Incandescent, 28 Volt, 40 MA	0501-016	Chicago Mini. Lamp	1819	18
F101	Fuse, Slo-Blo, 250 Volts, 1 Amp	1002-004	Buss	MDL	18
J101 and J102	Connectors, Receptacles, Coaxial, UG 560/u	1704-007	Amphenol	82-805	19
K101	Relay Kickout, .2 to .3 VDC, SP Mod. 1203-007	82761	Goerz		19
M101	Meter, 100-0-100 Microamps	715-013	Triplett	320R Custom Scale	19
R101	Resistor, Fixed Composition, 22 K, 1/2 Watt, ± 10%	0801-059	Al. Bradley	EB-2231	18
R102	Resistor, Fixed Power, 1000 Ohms, 8 Watts, ± 5%	0805-013	Ohmite	Brown Devil 1532	19
R103 thru R113	Resistor, Wire Wound, 3300 Ohms, ± 1%, 5 ppm/°C., -25°C, +75°C.	0802-382	RPC	LAC	22
R114	Resistor, Variable, Wire Wound, 5000 Ohms, 3 Watts, Mod 0806-080	54265	Clarostat	58-5000	18
R115	Resistor, Variable, Wire Wound, 50 Ohms, 3 Watts, Mod 0806-078	54266	Clarostat	58-50	18
R116 thru R126	Resistor, Wire Wound, 40 Ohms, 1%, 20 ppm/°C., -25°C, +75°C.	0802-375	RPC	LAC	22
R127	Resistor, Variable, Wire Wound 50 Ohms, 3 Watts, Mod 0806-078	54266	Clarostat	58-50	18

* Factory Selected - Approximate Value

Circuit Symbol	Description	Holt Part No.	Original Manufacturer	Original Manufacturer's Catalog No.	Figure
R128 thru R138	Resistor, Wire Wound, 40 Ohms, 1%, 20 ppm/°C., -25°C, +75°C.	0802-375	RPC	LAC	22
R139	Resistor, Composition, 12 K, 1 Watt, ± 10%	0801-137	Al. Bradley	GB1231	19
R140	Resistor, Variable, 100 K, 2 Watts, Mod 0806-047	54263	Ohmite	CU1041	18
R141	Resistor, Fixed, Metal Film, 51.1 Ohms, 1/2 Watt, ± 1%	0804-090	IRC	CEC-TO	19
R142	Resistor, Fixed, Metal Film, 511 Ohms, 1/2 Watt, ± 1%	0804-108	IRC	CEC-TO	19
R143	Resistor, Fixed, Metal Film, 4990 Ohms, 1/2 Watt, ± 1%	0804-135	IRC	CEC-TO	19
R144	Resistor, Fixed, Metal Film, 511 Ohms, 1/2 Watt, ± 1%	0804-108	IRC	CEC-TO	19
S101	Switch, Rotary, 6 Deck, 7 Pos.	84345			19
S102	Switch, Rotary, 1 Deck, 12 Pos.	1101-057	CTS		18
S103	Switch, Rotary, 1 Deck, 12 Pos.	1101-057	CTS		18
S104	Switch, Rotary, 1 Deck, 12 Pos.	1101-057	CTS		18
S105	Switch, Pushbutton, SPDT	1102-002	Switchcraft	FF-1003	18
S106	Switch, Pushbutton, SPDT	1102-002	Switchcraft	FF-1003	18
S107	Switch, Rotary, 2 Deck, 4 Pos.	1101-056	Oak		18
S108	Switch, Toggle, SPST	1103-003	AH & H	83001	18
T101	Transformer, Power, 115 VAC, 50/60 Hz., 64 VCT @ 900 MADC (Less cover)	1601-020	Thordarson	23V215	20

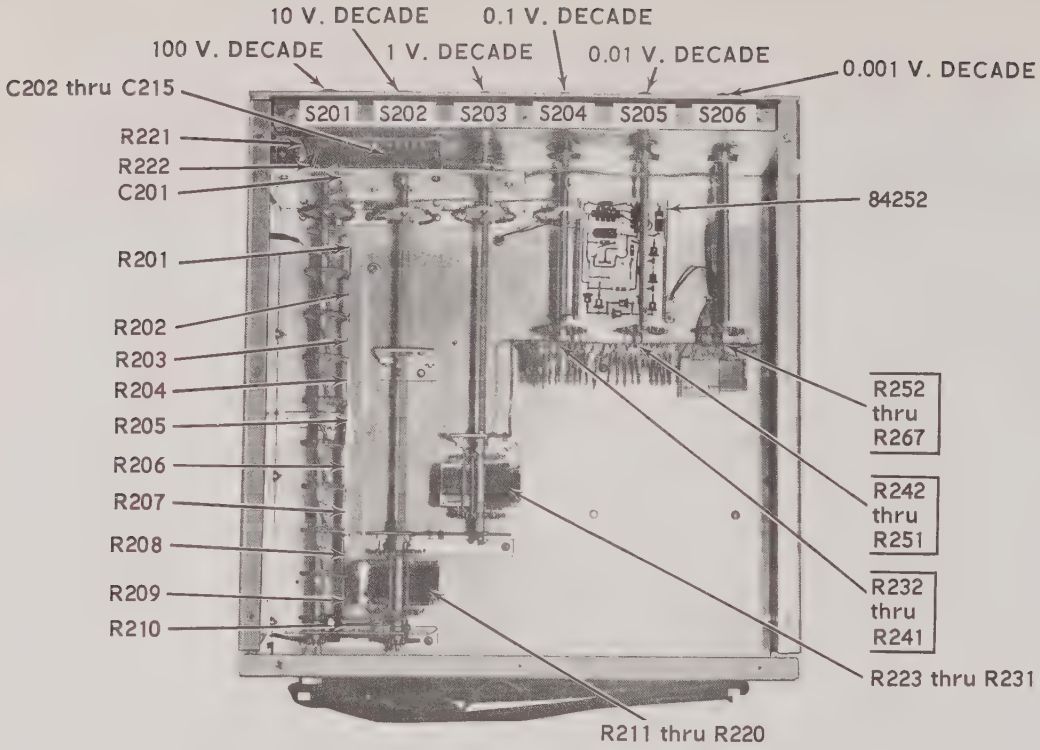


Figure 23. Main Attenuator Detail

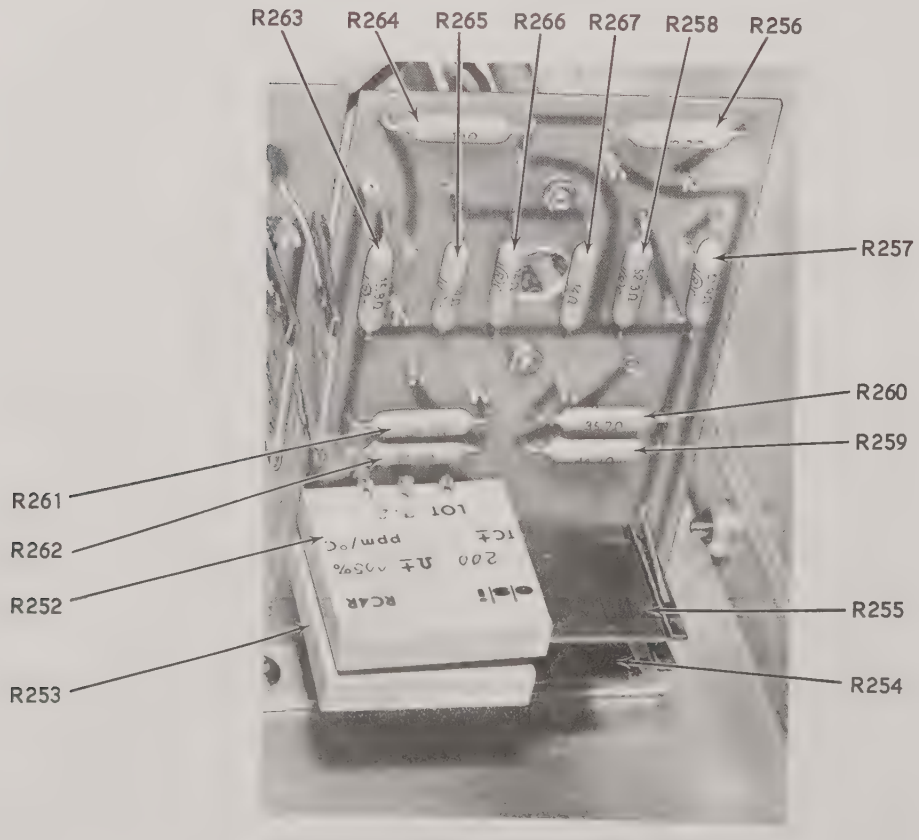


Figure 24. 0.001 Volt Decade Board Detail

LIST OF REPLACEABLE PARTS

Circuit Symbol	Description	Holt Part No.	Original Manufacturer	Original Manufacturer's Catalog No.	Figure
C201	Capacitor, Ceramic, 5000 VDC, 3 pf, ± 10%	0906-051	Centralab	855-3Z	23
C202	Capacitor, Mica, 150 pf, 500 Volts, ± 5%	0907-054	Arco-El	DM15-151J	23
C203 *	Capacitor, Mica, 50 pf, 500 Volts, ± 5%	0907-041	Arco-El	DM15-500	23
C204 *	Capacitor, Mica, 75 pf, 500 Volts, ± 5%	0907-046	Arco-El	DM15-750	23
C205 *	Capacitor, Mica, 160 pf, 500 Volts, ± 5%	0907-055	Arco-El	DM15-161J	23
C206 *	Capacitor, Mica, 220 pf, 500 Volts, ± 5%	0907-058	Arco-El	DM15-221J	23
C207 *	Capacitor, Mica, 120 pf, 500 Volts, ± 5%	0907-051	Arco-El	DM15-121	23
C208 *	Capacitor, Mica, 200 pf, 500 Volts, ± 5%	0907-057	Arco-El	DM15-201J	23
C209 *	Capacitor, Mica, 330 pf, 500 Volts, ± 5%	0907-064	Arco-El	DM15-331J	23
C210 *	Capacitor, Mica, 450 pf, 500 Volts, ± 1%	0907-068	Arco-El	DM15-451F	23
C211 *	Capacitor, Mica, 560 pf, 300 Volts, ± 5%	0907-005	Arco-El	DM15-561J	23
C212 *	Capacitor, Mica, 560 pf, 300 Volts, ± 5%	0907-005	Arco-El	DM15-561J	23
C213 *	Capacitor, Mica, 560 pf, 300 Volts, ± 5%	0907-005	Arco-El	DM15-561J	23
C214 *	Capacitor, Mica, 750 pf, 500 Volts, ± 5%	0907-009	Arco-El	DM19-751J	23
C215 *	Capacitor, Mica, 1200 pf, 500 Volts, ± 5%	0907-014	Arco-El	DM19-122J	23
R201 thru R209	Resistor, Wire Wound, 20 K Ohms, ± .005% Accuracy, ± .005% Stability, 2 ppm/°C.	0802-342	ESI	RF5R	23
R210 and R211	Resistor, Wire Wound, 19.8 K Ohms, ± .005% Accuracy, ± .005% Stability, 2 ppm/°C.	0802-341	ESI	RF5R	23
R212	Resistor, Wire Wound, 17.8 K Ohms, ± .005% Accuracy, ± .005% Stability, 2 ppm/°C.	0802-340	ESI	RF5R	23

* Factory Selected - Approximate Value

Circuit Symbol	Description	Holt Part No.	Original Manufacturer	Original Manufacturer's Catalog No.	Figure
R213	Resistor, Wire Wound, 15.8 K Ohms, ± .005% Accuracy, ± .005% Stability, 2 ppm/°C.	0802-339	ESI	RF5R	23
R214	Resistor, Wire Wound, 13.8 K Ohms, ± .005% Accuracy, ± .005% Stability, 2 ppm/°C.	0802-338	ESI	RF5R	23
R215	Resistor, Wire Wound, 11.8 K Ohms, ± .005% Accuracy, ± .005% Stability, 2 ppm/°C.	0802-337	ESI	RF5R	23
R216	Resistor, Wire Wound, 9800 Ohms, ± .005% Accuracy, ± .005% Stability, 2 ppm/°C.	0802-336	ESI	RF5R	23
R217	Resistor, Wire Wound, 7800 Ohms, ± .005% Accuracy, ± .005% Stability, 2 ppm/°C.	0802-335	ESI	RF5R	23
R218	Resistor, Wire Wound, 5800 Ohms, ± .005% Accuracy, ± .005% Stability, 2 ppm/°C.	0802-334	ESI	RF5R	23
R219	Resistor, Wire Wound, 3800 Ohms, ± .005% Accuracy, ± .005% Stability, 2 ppm/°C.	0802-333	ESI	RF5R	23
R220	Resistor, Wire Wound, 1800 Ohms, ± .005% Accuracy, ± .005% Stability, 2 ppm/°C.	0802-332	ESI	RF5R	23
R221 *	Resistor, Fixed, Composition, 5600 Ohms, 1/2 Watt, 10%	0801-053	Al. Bradley	EB5621	23
R222	Resistor, Variable, Composition, 10 K Ohms, 1/5 Watt	0806-058	Centralab	RV1LAXSB103A	23
R223	Resistor, Wire Wound, 1800 Ohms, ± .005% Accuracy, ± .005% Stability, 2 ppm/°C.	0802-328	ESI	RF4R	23
R224	Resistor, Wire Wound, 1600 Ohms, ± .005% Accuracy, ± .005% Stability, 2 ppm/°C.	0802-327	ESI	RF4R	23
R225	Resistor, Wire Wound, 1400 Ohms, ± .005% Accuracy, ±.005% Stability, 2 ppm/°C.	0802-326	ESI	RF4R	23
R226	Resistor, Wire Wound, 1200 Ohms, ± .005% Accuracy, ± .005% Stability, 2 ppm/°C.	0802-325	ESI	RF4R	23
R227	Resistor, Wire Wound, 1000 Ohms, ± .005% Accuracy, ± .005% Stability, 2 ppm/°C.	0802-324	ESI	RF4R	23

* Factory Selected - Approximate Value

Circuit Symbol	Description	Holt Part No.	Original Manufacturer	Original Manufacturer's Catalog No.	Figure
R228	Resistor, Wire Wound, 800 Ohms, ± .005% Accuracy, ± .005% Stability, 2 ppm/°C.	0802-323	ESI	RF4R	23
R229	Resistor, Wire Wound, 600 Ohms, ± .005% Accuracy, ± .005% Stability, 2 ppm/°C.	0802-322	ESI	RF4R	23
R230	Resistor, Wire Wound, 400 Ohms, ± .005% Accuracy, ± .005% Stability, 2 ppm/°C.	0802-321	ESI	RF4R	23
R231	Resistor, Wire Wound, 200 Ohms, ± .005% Accuracy, ± .005% Stability, 2 ppm/°C.	0802-317	ESI	RF4R	23
R232 thru R241	Resistor, Wire Wound, 20 Ohms, ± .01% ± 100 Micro Ohms Accuracy, ± .005% Stability, 15 ppm/°C.	0802-406	ESI	RF4R	23
R242 thru R251	Resistor, Wire Wound, 2 Ohms, ± .01% ± 100 Micro Ohms Accuracy, ± .005% Stability, 15 ppm/°C.	0802-405	ESI	RF4R	23
R252 and R253	Resistor, Wire Wound, 200 Ohms, ± .005% Accuracy, ± .005% Stability, 2 ppm/°C.	0802-389	ESI	RC4R	23,24
R254	Resistor, Wire Wound, 99 Ohms, ± .01%, 5 ppm/°C.	0802-330	ESI	RF5R	23,24
R255	Resistor, Wire Wound, 25.9 Ohms, ± .01% Accuracy, 5 ppm/°C.	0802-152	ESI	RF5R	23,24
R256	Resistor, Metal Film, 74.1 Ohms, 1/2 Watt, 1/4%	0804-271	IRC	CEC-TO	23,24
R257	Resistor, Metal Film, 62.9 Ohms, 1/2 Watt, 1/4%	0804-270	IRC	CEC-TO	23,24
R258	Resistor, Metal Film, 53 Ohms, 1/2 Watt, 1/4%	0804-269	IRC	CEC-TO	23,24
R259	Resistor, Metal Film, 44.2 Ohms, 1/2 Watt, 1/4%	0804-268	IRC	CEC-TO	23,24
R260	Resistor, Metal Film, 35.9 Ohms, 1/2 Watt, 1/2%	0804-267	IRC	CEC-TO	23,24
R261	Resistor, Metal Film, 28.7 Ohms, 1/2 Watt, 1/2%	0804-266	IRC	CEC-TO	23,24
R262	Resistor, Metal Film, 22.1 Ohms, 1/2 Watt, 1/2%	0804-265	IRC	CEC-TO	23,24
R263	Resistor, Metal Film, 15.8 Ohms, 1/2 Watt, 1%	0804-264	IRC	CEC-TO	23,24

Circuit Symbol	Description	Holt Part No.	Original Manufacturer	Original Manufacturer's Catalog No.	Figure
R264	Resistor, Metal Film, 10 Ohms, 1/2 Watt, 1%	0804-263	IRC	CEC-TO	23,24
R265 thru R267	Resistor, Metal Film, 14 Ohms, 1/2 Watt, 1%	0804-262	IRC	CEC-TO	23,24
S201	Switch, Rotary, 14 Deck, 11 Pos. 100 Volt Decade	84344			23
S202	Switch, Rotary, 6 Deck, 11 Pos. 10 Volt Decade	84343			23
S203	Switch, Rotary, 4 Deck, 11 Pos. 1 Volt Decade	84342			23
S204	Switch, Rotary, 2 Deck, 11 Pos. 0.1 Volt Decade	84341			23
S205	Switch, Rotary, 1 Deck, 11 Pos. 0.01 Volt Decade	84340			23
S206	Switch, Rotary, 1 Deck, 11 Pos. 0.001 Volt Decade	84339			23

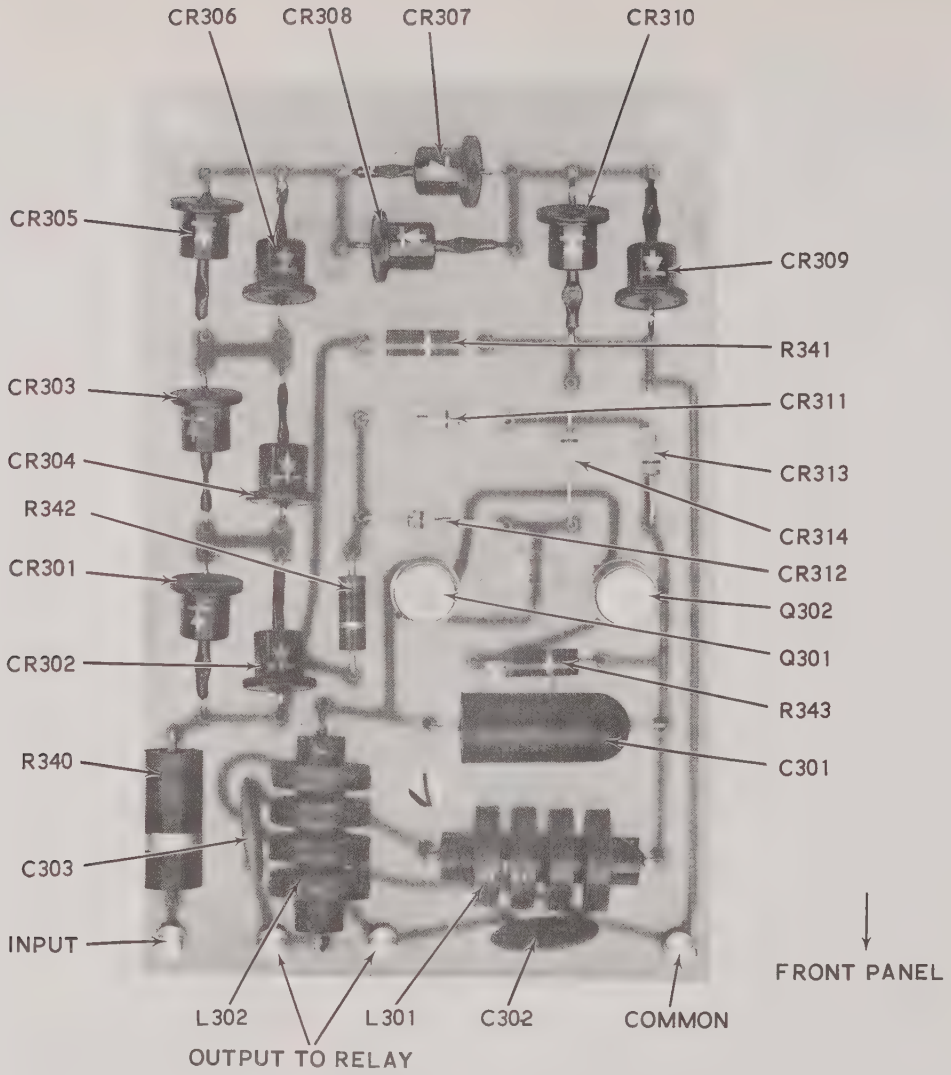


Figure 25. Relay Protection Circuit Board Detail

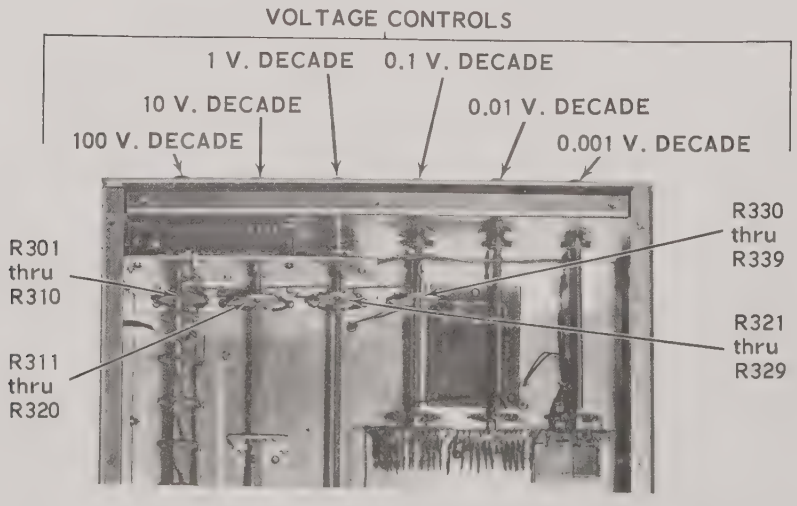


Figure 26. Relay Protection Circuit Attenuator

Circuit Symbol	Description	Holt Part No.	Original Manufacturer	Original Manufacturer's Catalog No.	Figure
C301	Capacitor, Tantalum, 200 microfarad, 10 Volts, ± 10%	0905-078	Kemet	K220C10K	25
C302	Capacitor, Ceramic, .01 microfarad, 600 Volts	0906-001	Centralab	DD6-103	25
C303	Capacitor, Ceramic, .01 microfarad, 600 Volts	0906-001	Centralab	DD6-103	25
CR301 thru CR310	Diode, Silicon, .75 A, 100 PIV	0301-016	RCA	1N440B	25
CR311 thru CR314	Diode, Germanium, 115 Volts, PIV, 50 MA	0302-005	Amperex	1N618	25
L301 and L302	Choke, R. F., 2.5 mh, Air Core	1502-009	National	R-50	25
Q301 and Q302	Transistor, Silicon, NPN, 800 mw, 40 Volts	0203-007	Sprague	TN-55	25
R301 thru R310	Resistor, Fixed Composition, 100 K Ohms, 1/2 Watt, 10%	0801-067	Al. Bradley	EB1041	26
R311 thru R320	Resistor, Fixed Composition, 10 K Ohms, 1/2 Watt, 10%	0801-056	Al. Bradley	EB1031	26
R321 thru R329	Resistor, Fixed Composition, 1000 Ohms, 1/2 Watt, 10%	0801-044	Al. Bradley	EB1021	26
R330 thru R339	Resistor, Fixed Composition, 100 Ohms, 1/2 Watt, 10%	0801-032	Al. Bradley	EB1011	26
R340	Resistor, Composition, 12 Ohms, 2 Watts, 10%	0801-153	Al. Bradley	HB1201	25
R341	Resistor, Composition, 1500 Ohms, 1/2 Watt, 10%	0801-046	Al. Bradley	EB1521	25
R342	Resistor, Composition, 1000 Ohms, 1/2 Watt, 10%	0801-044	Al. Bradley	EB1021	25
R343	Resistor, Composition, 8200 Ohms, 1/2 Watt, 10%	0801-055	Al. Bradley	EB8221	25

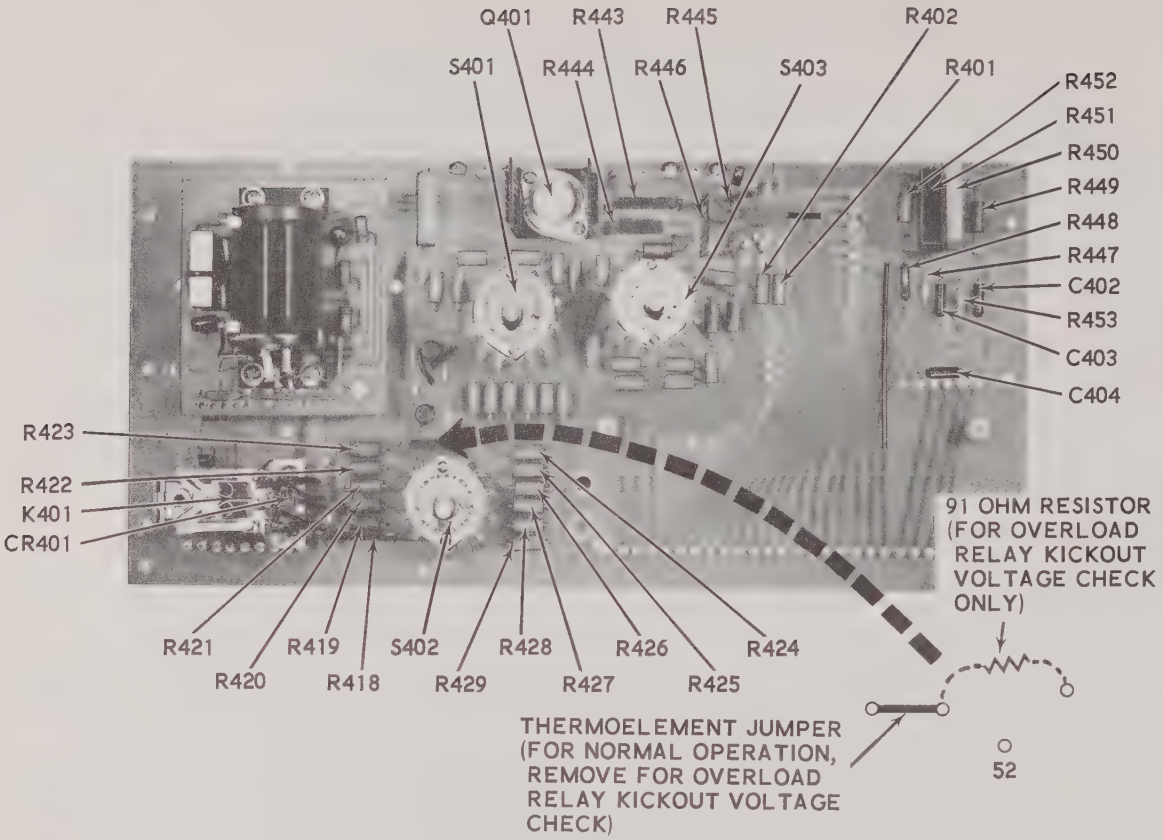


Figure 27. Main Circuit Board Detail No. 1

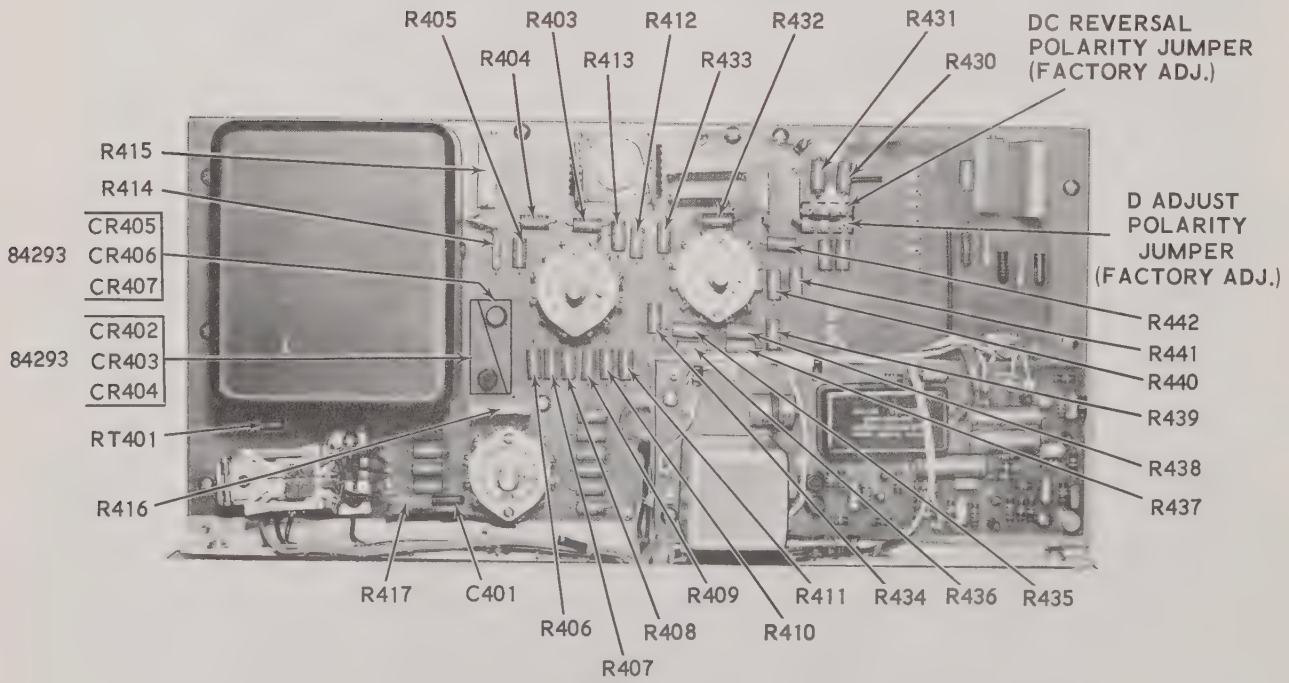


Figure 28. Main Circuit Board Detail No. 2

Circuit Symbol	Description	Holt Part No.	Original Manufacturer	Original Manufacturer's Catalog No.	Figure
C401 *	Capacitor, Mica, 500 Volts, 220 pf, ± 5%	0907-058	Arco-El	DM15-221J	28
C402	Capacitor, Electrolytic, 15 Volts, 22 microfarads, Tantalum, ± 10%	0905-077	Kemet	K22C15K	27
C403	Capacitor, Electrolytic, 15 Volts, 22 microfarads, Tantalum, ± 10%	0905-077	Kemet	K22C15K	27
C404	Capacitor, Mylar, 100 Volts, .01 microfarad, 10%	0903-058	Corn. Dub.	WMF1S1	27
CR402 CR403 CR404	Diodes, Matched Set	84293			28
CR405 CR406 CR407	Diodes, Matched Set	84293			28
K401	Relay, Switching, 60 Volts, 2500 Ohms, DPDT, Gold Contact	1203-023	Comar	XTJC-360	27
Q401	Transistor, Silicon, NPN, 100 Volts, 115 Watts	0203-011	RCA	2N3055	27
R401	Resistor, Wire Wound, 100 K Ohms, ± 1%, 20 ppm/°C., -25°C, +75°C.	0802-384	RPC	LAC	27
R402	Resistor, Wire Wound, 100 K Ohms, ± 1%, 20 ppm/°C., -25°C, +75°C.	0802-384	RPC	LAC	27
R403 thru R413	Resistor, Wire Wound, 600 K Ohms, ± 1%, 20 ppm/°C., -25°C, +75°C.	0802-385	RPC	LAC	28
R414	Resistor, Metal Film, 287 K Ohms, 1/2 Watt, ± 1%	0804-186	IRC	CEC-TO	28
R415	Resistor, Variable, 100 K, Wire Wound, 1/2 Watt	0806-082	Bourns	200L-2-104	28
R416	Resistor, Wire Wound, 1000 Ohms, ± .005% Accuracy, ± .005% Stability, 2 ppm/°C.	0802-324	ESI	RF4R	28
R417 *	Resistor, Metal Film, 1500 Ohms, 1/2 Watt, ± 1%	0804-121	IRC	CEC-TO	28
R418	Resistor, Wire Wound, 80 Ohms, ± .01% Accuracy, ± .005% Stability, 2 ppm/°C.	0802-386	ESI	RF5R	27
R419 thru R429	Resistor, Wire Wound, 3 Ohms, ± 1%, 20 ppm/°C., -25°C, +75°C.	0802-372	RPC	LAC	27
R430	Resistor, Wire Wound, 1 Ohm, ± 1%, 20 ppm/°C., -25°C, +75°C.	0802-371	RPC	LAC	28

* Factory Selected - Approximate Value

Circuit Symbol	Description	Holt Part No.	Original Manufacturer	Original Manufacturer's Catalog No.	Figure
R431	Resistor, Wire Wound, 1 Ohm, ± 1%, 20 ppm/°C., -25°C., +75°C.	0802-371	RPC	LAC	28
R432 thru R442	Resistor, Wire Wound, 3 Ohms, ± 1%, 20 ppm/°C., -25°C., +75°C.	0802-372	RPC	LAC	28
R443	Resistor, Wire Wound, 80 Ohms, ± .01% Accuracy, ± .005% Stability, 2 ppm/°C.	0802-386	ESI	RF5R	27
R444	Resistor, Wire Wound, 1000 Ohms, ± .005% Accuracy, ± .005% Stability, 2 ppm/°C.	0802-324	ESI	RF4R	27
R445	Resistor, Wire Wound, 1800 Ohms, ± .005% Accuracy, ± .005% Stability, 2 ppm/°C.	0802-328	ESI	RF4R	27
R446	Resistor, Wire Wound, 1800 Ohms, ± .005% Accuracy, ± .005% Stability, 2 ppm/°C.	0802-328	ESI	RF4R	27
R447	Resistor, Metal Film, 787 K Ohms, 1/2 Watt, ± 1%	0804-247	IRC	CEC-TO	27
R448	Resistor, Carbon Film, 7.87 Megohms, 1/2 Watt, ± 1%	0803-168	IRC	DCC	27
R449	Resistor, Wire Wound, 3800 Ohms, 0.1%, 20 ppm/°C., -25°C., +75°C.	0802-383	RPC	LAC	27
R450	Resistor, Wire Wound, 200 Ohms, ± .005% Accuracy, ± .005% Stability, 2 ppm/°C.	0802-389	ESI	RC4R	27
R451	Resistor, Variable, Wire Wound, 14 Turn, 100 Ohms, 3/4 Watt, 5%	0806-052	Clarostat	76JA-3-100	27
R452	Resistor, Wire Wound, 3100 Ohms, ± .01%, 5 ppm/°C., -25°C., +75°C.	0802-381	RPC	LAC	27
R453	Resistor, Metal Film, 100 K Ohms, 1/2 Watt, 1%	0804-170	IRC	CEC-TO	27
RT401	Thermistor, Disc., 5000 Ohms, 10%, -3.9%/°C.	0403-006	Fenwal	KA35J3	28
S401	Switch, Rotary, 2 Deck, 12 Pos., D COARSE	1101-059			27
S402	Switch, Rotary, 1 Deck, 12 Pos., B and D COARSE	1101-058			27
S403	Switch, Rotary, 1 Deck, 12 Pos., B and D COARSE	1101-058			27

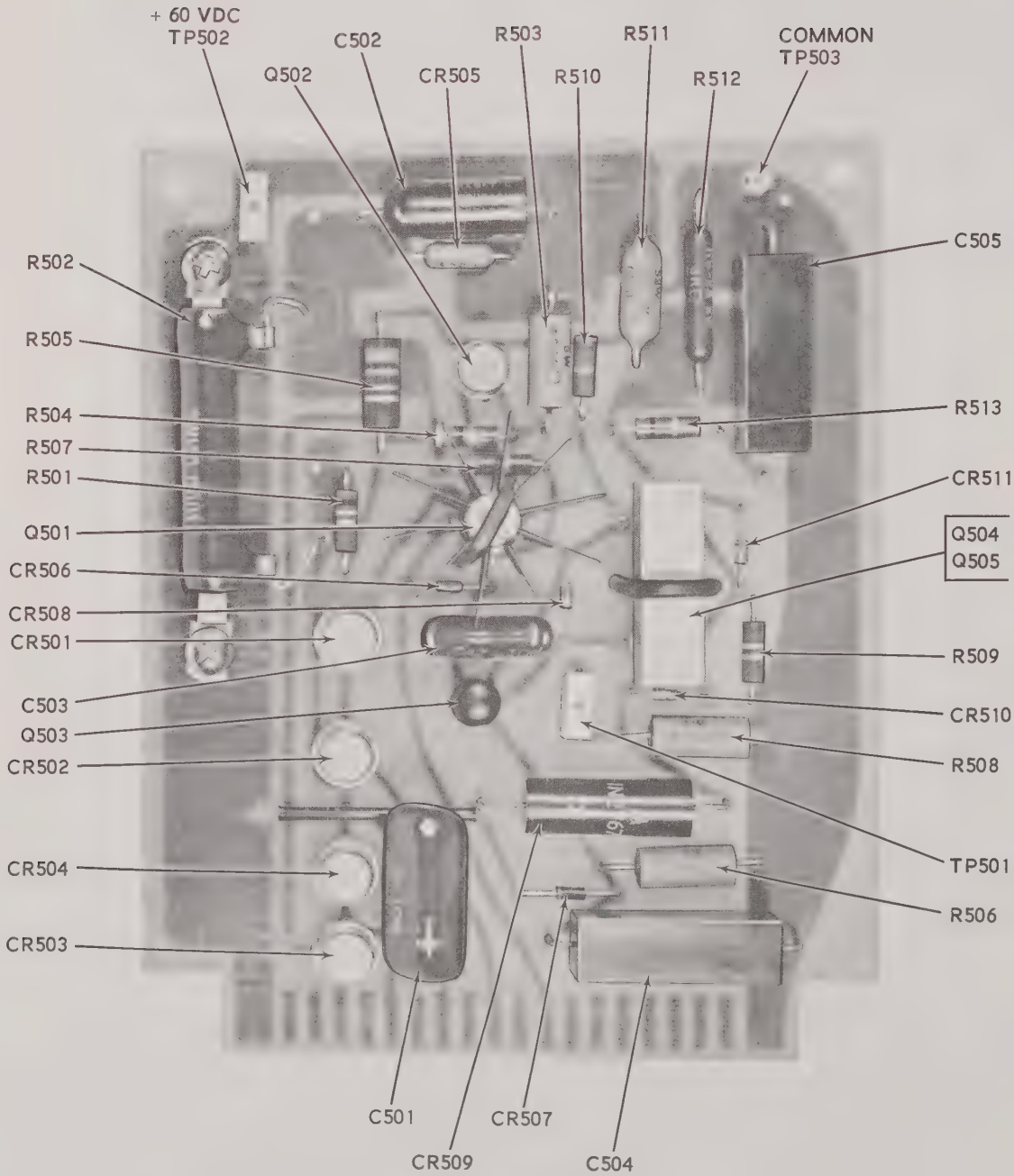


Figure 29. + 60 VDC Power Supply Board Detail

LIST OF REPLACEABLE PARTS

Circuit Symbol	Description	Holt Part No.	Original Manufacturer	Original Manufacturer's Catalog No.	Figure
C501	Capacitor, Mylar, .1 microfarad, 400 VDC, ± 10%	0903-031	ARCO-EL	4DP-3-104 10525	29
C502	Capacitor, Tantalum, 220 microfarads, 10 VDC, ± 10%	0905-078	Kemet	K220J10K	29
C503	Capacitor, Mylar, .047 microfarad, 100 Volts, ± 10%	0903-008	ARCO-EL	1DP-2-473	29
C504	Capacitor, Metallized Mylar, 1 microfarad, 200 Volts	0904-004	El. Prod.	DE2-105	29
C505	Capacitor, Metallized Mylar, 1 microfarad, 200 Volts	0904-004	El. Prod.	DE2-105	29
CR501	Diode, Semi-conductor, Silicon, 200 PIV, 3 Amp	0301-029	Motorola	MR1032B	29
CR502	Diode, Semi-conductor, Silicon, 200 PIV, 3 Amp	0301-029	Motorola	MR1032B	29
CR503	Diode, Semi-conductor, Silicon, 200 PIV, 3 Amp	0301-029	Motorola	MR1032B	29
CR504	Diode, Semi-conductor, Silicon, 200 PIV, 3 Amp	0301-029	Motorola	MR1032B	29
CR505	Zener, Semi-conductor, 6.2 Volts, ± 20%	0303-017	Schauer	SZ6.2	29
CR506	Diode, Semi-conductor, 125 PIV, 4 MA	0301-003	Hughes	IN628	29
CR507	Zener, Semi-conductor, 10 Volts, 1 Watt	0303-024	Semcor	LPM-10A	29
CR508	Diode, Semi-conductor, 125 PIV, 4 MA	0301-003	Hughes	IN628	29
CR509	Zener, Semi-conductor, 20.4 Volts, 5%, .005%° C.	0303-018	Motorola	IN2767	29
CR510	Diode, Semi-conductor, 125 PIV, 4 MA	0301-003	Hughes	IN628	29
CR511	Diode, Semi-conductor, 125 PIV, 4 MA	0301-003	Hughes	IN628	29
Q501	Transistor, NPN, Silicon, 100 VDC, 4 Watts	0203-025	T. I.	2N657	29
Q502	Transistor, NPN, Silicon, 120 VDC, 600 MW	0203-023	T. I.	2N699	29
Q503	Transistor, NPN, Silicon, 60 VDC, 700 MW	0203-024	Fairchild	2N3643	29
Q504	Transistor, NPN, Silicon, 60 VDC, 700 MW	0203-024	Fairchild	2N3643	29
Q505	Transistor, NPN, Silicon, 60 VDC, 700 MW	0203-024	Fairchild	2N3643	29

Circuit Symbol	Description	Holt Part No.	Original Manufacturer	Original Manufacturer's Catalog No.	Figure
R501	Resistor, Fixed Composition, 100 K, 1/2 Watt, ± 10%	0801-067	Al. Bradley	EB1041	29
R502	Resistor, Power, 1000 Ohms, 12 Watts, ± 5%	0805-034	Ohmite	1736	29
R503	Resistor, Wire Wound, 4000 Ohms, 3 Watts, 5%	0802-276	Sprague	450E4025	29
R504	Resistor, Fixed Composition, 47 Ohms, 1/2 Watt, 10%	0801-028	Al. Bradley	EB4701	29
R505	Resistor, Wire Wound, 2.7 Ohms, 2 Watts, ± 10%	0802-126	IRC	BWH	29
R506	Resistor, Wire Wound, 5000 Ohms, 3 Watts, ± 5%	0802-277	Sprague	450E5025	29
R507	Resistor, Fixed Composition, 1200 Ohms, 1/2 Watt, 10%	0801-045	Al. Bradley	EB1221	29
R508	Resistor, Wire Wound, 3000 Ohms, 3 Watts, ± 5%	0802-279	Sprague	450E3025	29
R509	Resistor, Fixed Composition, 22 K Ohms, 1/2 Watt, 10%	0801-059	Al. Bradley	EB2231	29
R510	Resistor, Fixed Composition, 8200 Ohms, 1/2 Watt, 10%	0801-055	Al. Bradley	EB8221	29
R511	Resistor, Wire Wound, 2560 Ohms, 2 Watts, ± 1%	0802-253	Sage	S-2W	29
R512	Resistor, Power, 5000 Ohms, 2 Watts, 1%	0805-081	Dale	RS-2A	29
R513	Resistor, Fixed Composition, 1000 Ohms, 1/2 Watt, 10%	0801-044	Al. Bradley	EB1021	29

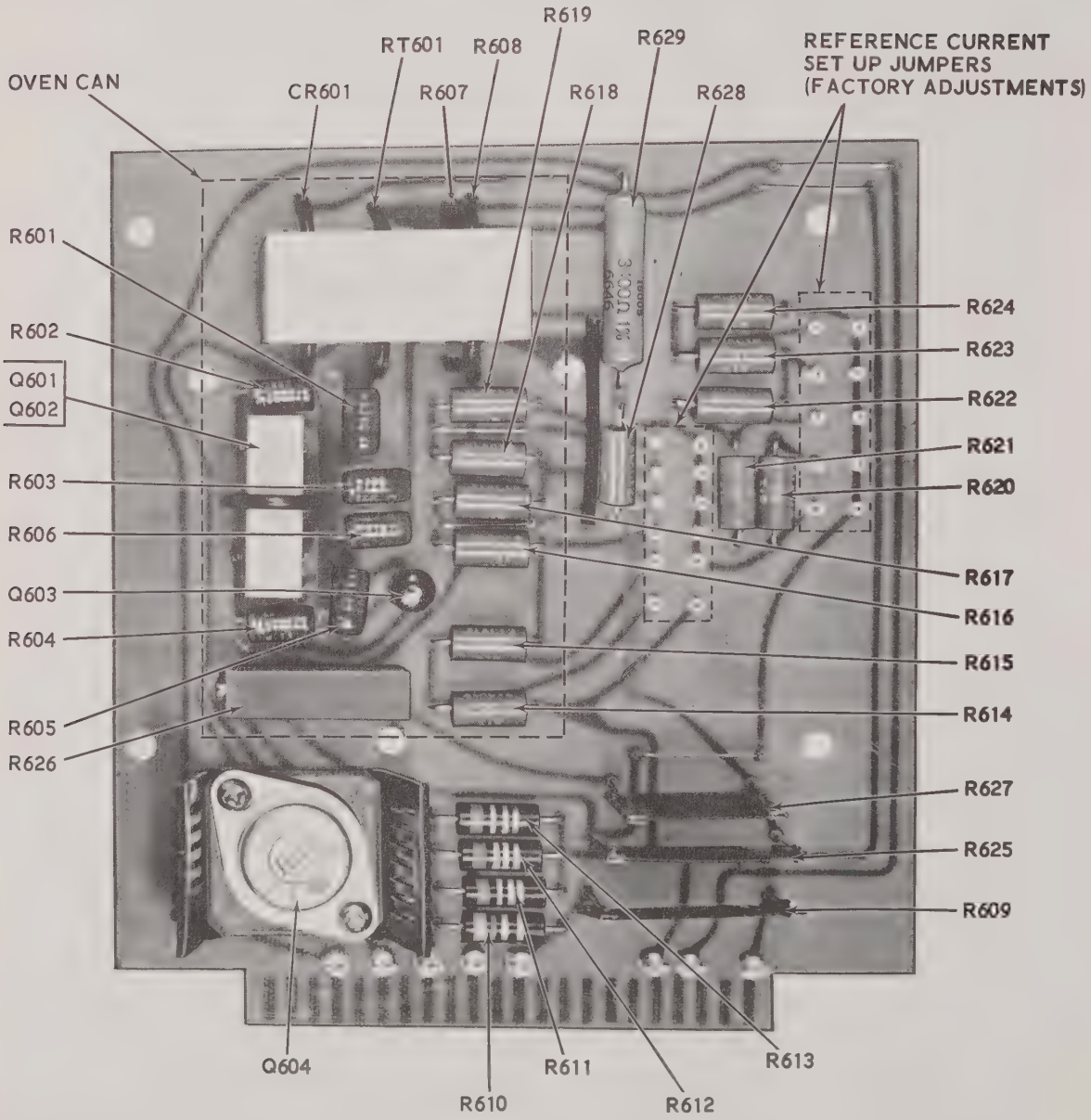


Figure 30. Reference Oven Board Detail

Circuit Symbol	Description	Holt Part No.	Original Manufacturer	Original Manufacturer's Catalog No.	Figure
CR601 **	Zener, Semi-conductor, 6.2 Volts to 6.5 Volts, 7.5 MA, 20 ppm stability for 3 months, 5 ppm/° C.	0303-031		1N3504A	30
Q601	Transistor, Silicon, NPN, 60 Volts, 800 MW	0203-020	Fairchild	2N3568	30
Q602	Transistor, Silicon, NPN, 60 Volts, 800 MW	0203-020	Fairchild	2N3568	30
Q603	Transistor, Silicon, NPN, 60 Volts, 800 MW	0203-020	Fairchild	2N3568	30
Q604	Transistor, Silicon, NPN 100 Volts, 115 Watts	0203-011	RCA	2N3055	30
R601	Resistor, Power, 6200 Ohms, 1 Watt, ± 5%	0805-103	RCL	T1A	30
R602	Resistor, Power, 10 K Ohms, 3 Watts, ± 5%	0805-093	Ohmite	2808	30
R603	Resistor, Wire Wound, 360 Ohms, 1 Watt, ± 5%	0802-407	Ward Leonard	1X	30
R604	Resistor, Power 10 K Ohms, 3 Watts, ± 5%	0805-093	Ohmite	2808	30
R605	Resistor, Power, 6200 Ohms, 1 Watt, ± 5%	0805-103	RCL	T1A	30
R606	Resistor, Power, 270 Ohms, 3 Watts, ± 5%	0805-090	Ohmite	2770	30
R607	Resistor, Wire Wound, 820 Ohms, 2 Watts, ± 5%	0802-363	IRC	BWH	30
R608	Resistor, Wire Wound, 820 Ohms, 2 Watts, ± 5%	0802-363	IRC	BWH	30
R609	Resistor, Wire Wound, 500 Ohms, ± .005% Accuracy, ± .005% Stability, 2 ppm/° C.	0802-387	ESI	RF5R	30
R610	Resistor, Wire Wound, .82 Ohms, 2 Watts, ± 10%	0802-122	IRC	BWH	30
R611	Resistor, Wire Wound, .24 Ohms, 2 Watts, ± 5%	0802-390	IRC	BWH	30
R612	Resistor, Wire Wound, .24 Ohms, 2 Watts, ± 5%	0802-390	IRC	BWH	30
R613	Resistor, Wire Wound, .24 Ohms, 2 Watts, ± 5%	0802-390	IRC	BWH	30
R614	Resistor, Wire Wound, 3 Ohms, ± 1%, 20 ppm/° C., -25° C. to + 75° C.	0802-372	RPC	LAC	30

Circuit Symbol	Description	Holt Part No.	Original Manufacturer	Original Manufacturer's Catalog No.	Figure
R615	Resistor, Wire Wound, 30 Ohms, ± 1%, 20 ppm/°C., -25° C to +75° C.	0802-374	RPC	LAC	30
R616	Resistor, Wire Wound, 30 Ohms, ± 1%, 20 ppm/°C., -25° C to +75° C.	0802-374	RPC	LAC	30
R617	Resistor, Wire Wound, 30 Ohms, ± 1%, 20 ppm/°C, -25° C to +75° C.	0802-374	RPC	LAC	30
R618	Resistor, Wire Wound, 30 Ohms, ± 1%, 20 ppm/°C., -25° C to +75° C.	0802-374	RPC	LAC	30
R619	Resistor, Wire Wound, 30 Ohms, ± 1%, 20 ppm/°C., -25°C to +75° C.	0802-374	RPC	LAC	30
R620	Resistor, Wire Wound, 5 Ohms, ± 1%, 20 ppm/°C., -25° C to +75° C.	0802-373	RPC	LAC	30
R621	Resistor, Wire Wound, 5 Ohms, ± 1%, 20 ppm/°C., -25° C to +75° C.	0802-373	RPC	LAC	30
R622	Resistor, Wire Wound, 5 Ohms, ± 1%, 20 ppm/°C., -25° C to +75° C.	0802-373	RPC	LAC	30
R623	Resistor, Wire Wound, 5 Ohms, ± 1%, 20 ppm/°C., -25° C to +75° C.	0802-373	RPC	LAC	30
R624	Resistor, Wire Wound, 5 Ohms, ± 1%, 20 ppm/°C., -25° C to +75° C.	0802-373	RPC	LAC	30
R625	Resistor, Wire Wound, 300 Ohms, ± .005% accuracy, ± .005% stability, 2 ppm/°C.	0802-388	ESI	RF5R	30
R626	Resistor, Variable, Wire Wound, 100 Ohms, 3/4 Watt, ± 5%	0806-052	Clarostat	76JA-3-100	30
R627	Resistor, Wire Wound, 1000 Ohms, ± .005% accuracy, ± .005% stability, 2 ppm/°C.	0802-324	ESI	RF4R	30
R628 *	Resistor, Wire Wound, 200 Ohms, 1%, 10 ppm/°C., -25° C to +75° C.	0802-377	RPC	LAC	30
R629	Resistor, Power, 3400 Ohms, ± 1%, 7 Watts	0805-099	Sage	SS7W	30
RT601	Thermistor, Bead, 2000 Ohms, ±10%, -3.9%/°C.	0403-007	Fenwal	GB32R1	30

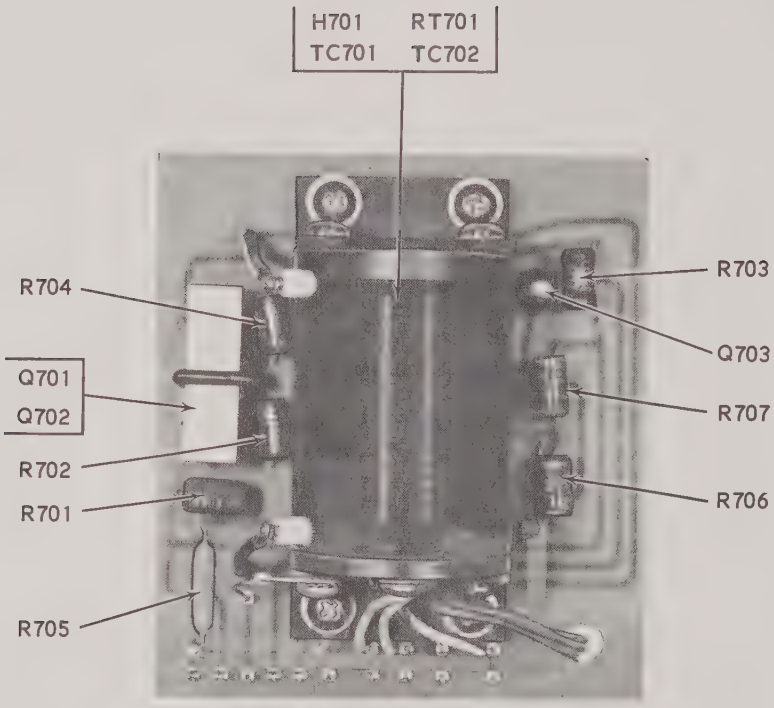


Figure 31. Thermal Converter Oven Board Detail

Circuit Symbol	Description	Holt Part No.	Original Manufacturer	Original Manufacturer's Catalog No.	Figure
Q701	Transistor, Silicon, NPN, 60 volts, 800 millivolts	0203-020	Fairchild	2N3568	31
Q702	Transistor, Silicon, NPN, 60 volts, 800 millivolts	0203-020	Fairchild	2N3568	31
Q703	Transistor, Silicon, NPN, 60 volts, 800 millivolts	0203-020	Fairchild	2N3568	31
R701	Resistor, Power, 6200 Ohms, 1 Watt, ± 5%	0805-103	RCL	T1A	31
R702	Resistor, Power 10K Ohms, 3 Watts, ± 5%	0805-093	Ohmite	2808	31
R703	Resistor, Wire Wound, 360 Ohms, 1 Watt, ± 5%	0802-407	Ward Leonard	1X	31
R704	Resistor, Power, 10 K Ohms, 3 Watts, ± 5%	0805-093	Ohmite	2808	31
R705	Resistor, M. F., 30.1 K Ohms, 1/2 Watt, 1%	0804-159	IRC	CEC-TO	31
R706	Resistor, Power, 6200 Ohms, 1 Watt, ± 5%	0805-103	RCL	T1A	31
R707	Resistor, Power, 270 Ohms, 3 Watts, ± 5%	0805-090	Ohmite	2770	31
RT701	Thermistor, Bead, 2 K Ohms, ± 10%, 3.9%/° C.	0403-007	Fenwal	GB32R1	31
TC701 TC702 Matched Pair	Thermoelements, Matched Set	0401-008			31
H701	Wire, Resistance, 12 Ohms/ft., #36, Manganin	8507-003	Wilb. Driver		31

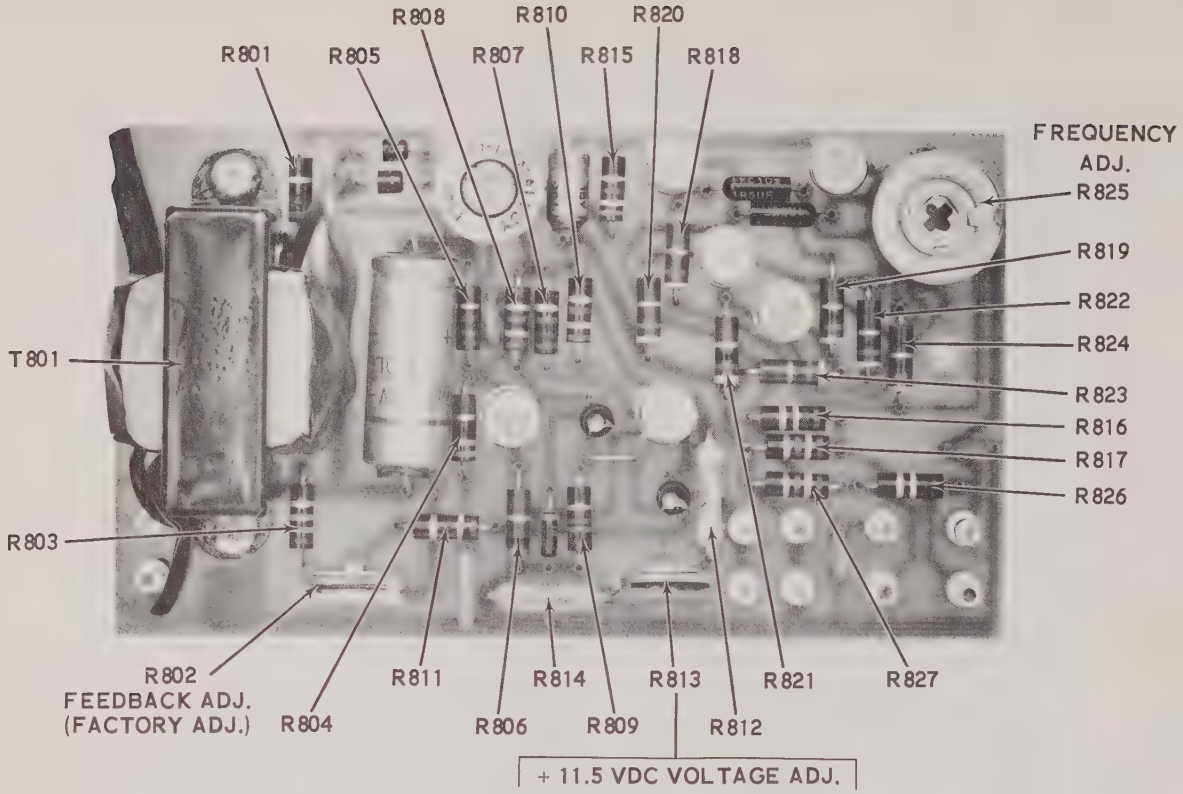


Figure 32. Null Detector Power Supply Board (Detail 1)

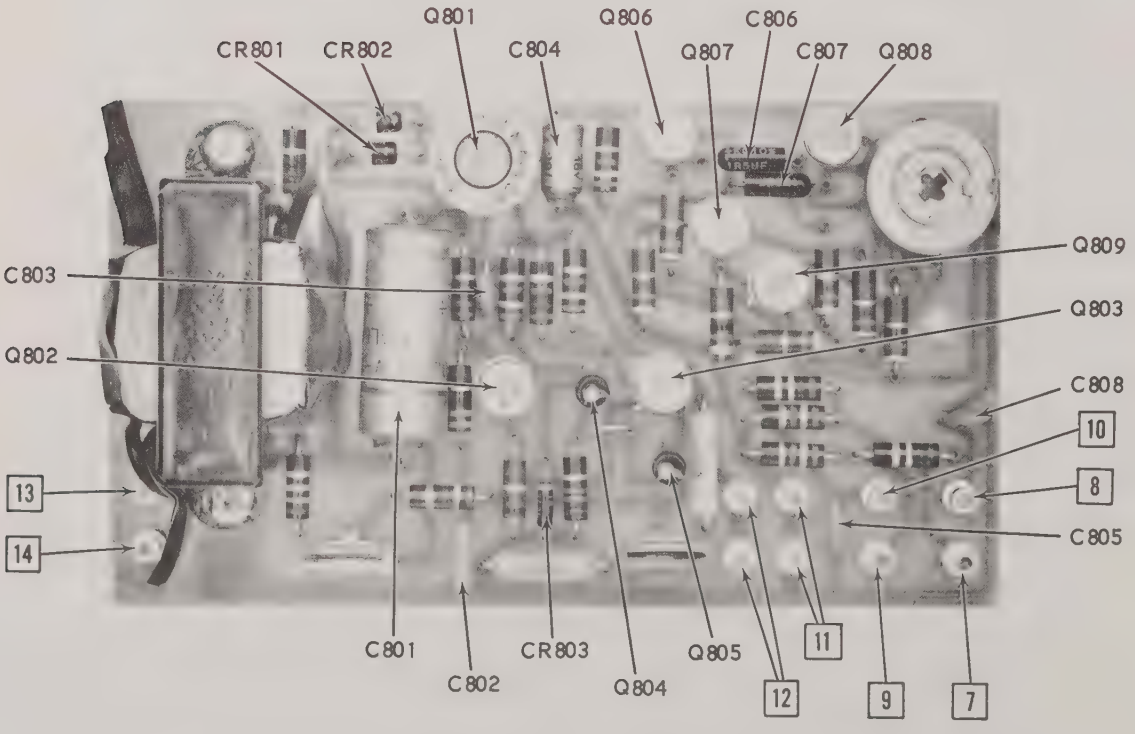


Figure 33. Null Detector Power Supply Board (Detail 2)

Circuit Symbol	Description	Holt Part No.	Original Manufacturer	Original Manufacturer's Catalog No.	Figure
C801	Capacitor, Electrolytic, 250 mfd, 25 Volts	315-111	Amperex	C437 AR/F250	33
C802	Capacitor, Flat Foil, .022 mfd, 40 Volts	326-108	Amperex	C280 AA/P22K	33
C803	Capacitor, Ceramic Disc, .001 mfd, 1 KV	326-101	Sprague	10292	33
C804	Capacitor, Electrolytic, 20 mfd, 16 Volts	315-104	Amperex	C426 AR/E20	33
C805	Capacitor, Ceramic Disc, .001 mfd, 1 KV	326-101	Sprague	10292	33
C806	Capacitor, Tantalum, 1.5 mfd, 20 Volts	311-109	Kemet	KIR5C20K	33
C807	Capacitor, Tantalum, 1.5 mfd, 20 Volts	311-109	Kemet	KIR5C20K	33
C808	Capacitor, Ceramic Disc, .001 mfd, 1 KV	326-101	Sprague	10292	33
CR801	Diode, Silicon, Rectifier, 4D4	416-272	IRC	4D4	33
CR802	Diode, Silicon, Rectifier, 4D4	416-272	IRC	4D4	33
CR803	Diode, Zener, 6.2 Volts, 1N753A	421-105	IRC	1N753A	33
Q801	Transistor, Silicon, NPN	440-001	RCA	2N3053	33
Q802 and Q803	Transistor, Germanium, NPN	432-004	Texas Inst.	2N1304	33
Q804 and Q805	Transistor, Silicon, NPN	440-003	GE	2N2926	33
Q806	Transistor, Germanium, PNP	432-005	RCA	2N1305	33
Q807	Transistor, Germanium, NPN	432-004	Texas Inst.	2N1304	33
Q808	Transistor, Germanium, PNP	432-005	RCA	2N1305	33
Q809	Transistor, Germanium, NPN	432-004	Texas Inst.	2N1304	33
R801	Resistor, Fixed Composition, 15 Ohms, 1/2 Watt, 10%	153-150	Stackpole	RC20	32
R802	Potentiometer, Carbon, Tab Mount, 50 K	215-206	Chi. Tel.	1714, type X201	32
R803	Resistor, Fixed Composition, 18 K, 1/2 Watt, 10%	153-183	Stackpole	RC20	32
R804	Resistor, Fixed Composition, 33 Ohms, 1/2 Watt, 10%	153-330	Stackpole	RC20	32
R805	Resistor, Fixed Composition, 2200 Ohms, 1/2 Watt, 10%	153-222	Stackpole	RC20	32
R806	Resistor, Fixed Composition, 1000 Ohms, 1/2 Watt, 10%	153-102	Stackpole	RC20	32
R807	Resistor, Fixed Composition, 1500 Ohms, 1/2 Watt, 10%	153-152	Stackpole	RC20	32
R808	Resistor, Fixed Composition, 6800 Ohms, 1/2 Watt, 10%	153-682	Stackpole	RC20	32

Circuit Symbol	Description	Holt Part No.	Original Manufacturer	Original Manufacturer's Catalog No.	Figure
R809	Resistor, Fixed Composition, 5600 Ohms, 1/2 Watt, 10%	153-562	Stackpole	RC20	32
R810	Resistor, Fixed Composition, 6800 Ohms, 1/2 Watt, 10%	153-682	Stackpole	RC20	32
R811	Resistor, Fixed Composition, 2.7 Megohms, 1/2 Watt, 10%	153-275	Stackpole	RC20	32
R812	Resistor, Fixed Metal Film, 4020 Ohms, 1/2 Watt, 1%	157-022	IRC	CEC-TO	32
R813	Potentiometer, Carbon, Tab Mount, 2500 Ohms	215-205	Chi. Tel.	1712, type X201	32
R814	Resistor, Fixed Metal Film, 6490 Ohms, 1/2 Watt, 1%	157-017	IRC	CEC-TO	32
R815	Resistor, Fixed Composition, 390 Ohms, 1/2 Watt, 10%	153-391	Stackpole	RC20	32
R816 *	Resistor, Fixed Composition, 150 K, 1/2 Watt, 10%	153-154	Stackpole	RC20	32
R817	Resistor, Fixed Composition, 2700 Ohms, 1/2 Watt, 10%	153-272	Stackpole	RC20	32
R818 * thru R820	Resistor, Fixed Composition, 4700 Ohms, 1/2 Watt, 10%	153-472	Stackpole	RC20	32
R821	Resistor, Fixed Composition, 47 Ohms, 1/2 Watt, 10%	153-470	Stackpole	RC20	32
R822 thru R824 *	Resistor, Fixed Composition, 4.7 K, 1/2 Watt, 10%	153-472	Stackpole	RC20	32
R825	Potentiometer, Wire Wound, PC Mount, 500 ohms	261-501	CTS	BA22895, type 110	32
R826 *	Resistor, Fixed Composition, 150 K, 1/2 Watt, 10%	153-154	Stackpole	RC20	32
R827	Resistor, Fixed Composition, 2700 Ohms, 1/2 Watt, 10%	153-272	Stackpole	RC20	32
T801	Transformer, Power	705-002	Triad	F94-X	32

* Factory Selected - Approximate Value

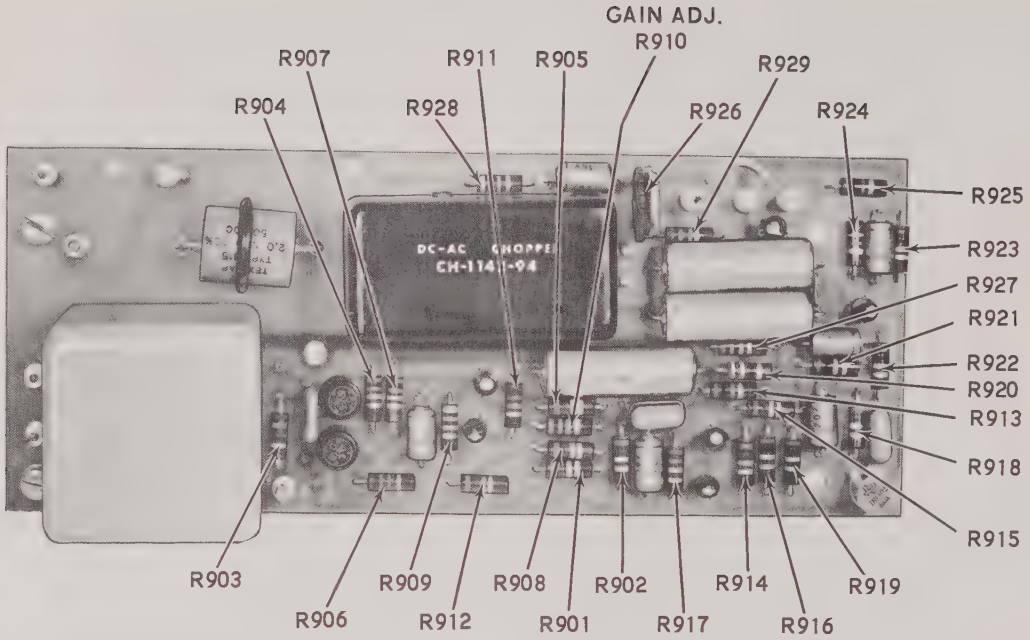


Figure 34. Null Detector Amplifier Board (Detail 1)

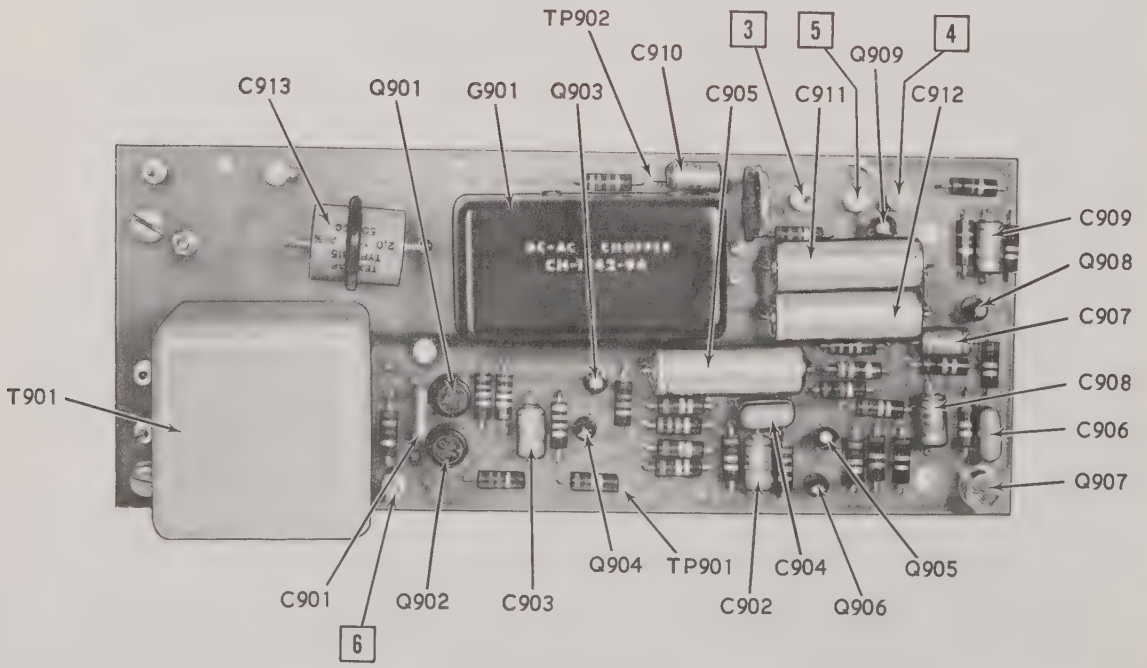


Figure 35. Null Detector Amplifier Board (Detail 2)

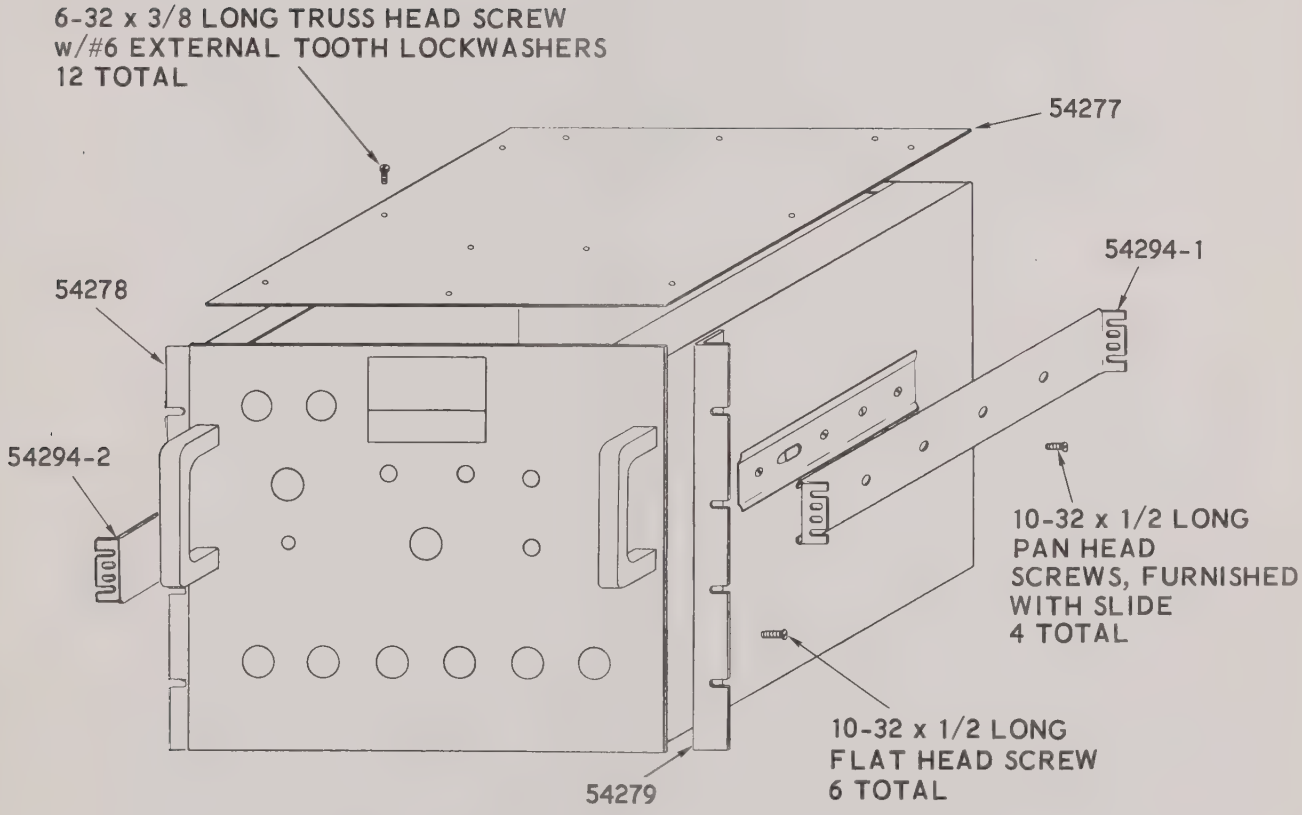
Circuit Symbol	Description	Holt Part No.	Original Manufacturer	Original Manufacturer's Catalog No.	Figure
C901	Capacitor, Flat Foil, .022 mfd, 40 Volts	326-108	Amperex	C280 AA/P22K	35
C902	Capacitor, Electrolytic, 20 mfd, 16 Volts	315-104	Amperex	C426 AR/E20	35
C903	Capacitor, Electrolytic, 20 mfd, 16 Volts	315-104	Amperex	C426 AR/E20	35
C904	Capacitor, Flat Foil, .1 mfd, 40 Volts	326-107	Amperex	C280 AA/P100K	35
C905	Capacitor, Electrolytic, 250 mfd, 16 Volts	315-109	Amperex	C437 AR/E250	35
C906	Capacitor, Flat Foil, .1 mfd, 40 Volts	326-107	Amperex	C280 AA/P100K	35
C907 thru C910	Capacitor, Electrolytic, 20 mfd, 16 Volts	315-104	Amperex	C426 AR/E20	35
C911 and C912	Capacitor, Electrolytic, 250 mfd, 16 Volts	315-109	Amperex	C437 AR/E250	35
C913	Capacitor, Metallized Mylar, 2 mfd,50 Volts	0904-023	Texas Cap	315-205A	35
G901	Chopper, DPDT, Non-resonant	701-002	Stevens	CH-MD12-12/94	35
Q901	Transistor, Germanium, PNP	432-009	GE	2N508A	35
Q902	Transistor, Germanium, PNP	432-009	GE	2N508A	35
Q903 thru Q906	Transistor, Silicon, NPN	440-003	GE	2N2926	35
Q907	Transistor, Germanium, PNP	432-005	RCA	2N1305	35
Q908 and Q909	Transistor, Silicon, NPN	440-003	GE	2N2926	35
R901 and R902	Resistor, Fixed, Composition, 15 K, 1/2 Watt, 10%	153-153	Stackpole	RC20	34
R903	Resistor, Fixed Composition, 18 Megohms, 1/2 Watt, 10%	153-186	Stackpole	RC20	34
R904	Resistor, Fixed Composition, 22 K, 1/2 Watt, 10%	153-223	Stackpole	RC20	34
R905	Resistor, Fixed Composition, 15 K, 1/2 Watt, 10%	153-153	Stackpole	RC20	34
R906	Resistor, Fixed Composition, 560 Ohms, 1/2 Watt, 10%	153-561	Stackpole	RC20	34
R907	Resistor, Fixed Composition, 22 K, 1/2 Watt, 10%	153-223	Stackpole	RC20	34
R908	Resistor, Fixed Composition, 15 K, 1/2 Watt, 10%	153-153	Stackpole	RC20	34
R909	Resistor, Fixed Composition, 33K, 1/2 Watt, 10%	153-333	Stackpole	RC20	34

Circuit Symbol	Description	Holt Part No.	Original Manufacturer	Original Manufacturer's Catalog No.	Figure
R910	Resistor, Fixed Composition, 1200 Ohms, 1/2 Watt, 10%	153-122	Stackpole	RC20	34
R911	Resistor, Fixed Composition, 5600 Ohms, 1/2 Watt, 10%	153-562	Stackpole	RC20	34
R912	Resistor, Fixed Composition, 1500 Ohms, 1/2 Watt, 10%	153-152	Stackpole	RC20	34
R913	Resistor, Fixed Composition, 1000 Ohms, 1/2 Watt, 10%	153-102	Stackpole	RC20	34
R914	Resistor, Fixed Composition, 15 K, 1/2 Watt, 10%	153-153	Stackpole	RC20	34
R915	Resistor, Fixed Composition, 15 K, 1/2 Watt, 10%	153-153	Stackpole	RC20	34
R916	Resistor, Fixed Composition, 100 K, 1/2 Watt, 10%	153-104	Stackpole	RC20	34
R917	Resistor, Fixed Composition, 12 K, 1/2 Watt, 10%	153-123	Stackpole	RC20	34
R918	Resistor, Fixed Composition, 15 K, 1/2 Watt, 10%	153-153	Stackpole	RC20	34
R919	Resistor, Fixed Composition, 100 K, 1/2 Watt, 10%	153-104	Stackpole	RC20	34
R920 *	Resistor, Composition, 47 Ohms, 1/2 Watt, 10%	153-470	Stackpole	RC20	34
R921 thru R923	Resistor, Fixed Composition, 10 K, 1/2 Watt, 10%	153-103	Stackpole	RC20	34
R924	Resistor, Fixed Composition, 6800 Ohms, 1/2 Watt, 10%	153-682	Stackpole	RC20	34
R925	Resistor, Fixed Composition, 1000 Ohms, 1/2 Watt, 10%	153-102	Stackpole	RC20	34
R926	Potentiometer, Carbon, Tab Mount, 50 K	215-206	Chi. Tel.	1714, type X201	34
R927	Resistor, Composition, 18 K, 1/2 Watt, 10%	153-183	Stackpole	RC20	34
R928	Resistor, Composition, 820 Ohms, 1/2 Watt, 10%	153-821	Stackpole	RC20	34
R929	Resistor, Composition, 1200 Ohms, 1/2 Watt, 10%	153-122	Stackpole	RC20	34
T901	Transformer, Input	705-101	Nytronics	705-101	35
	Circuit Board, Smaller	900-033C	Medistor	900-033C	35
	Circuit Board, Larger	900-034C	Medistor	900-033C	35

* Factory Selected - Approximate Value

RACK MOUNTING ACCESSORY KIT

FOR HOLT MODEL 10
AC-DC THERMAL VOLTMETER STANDARD



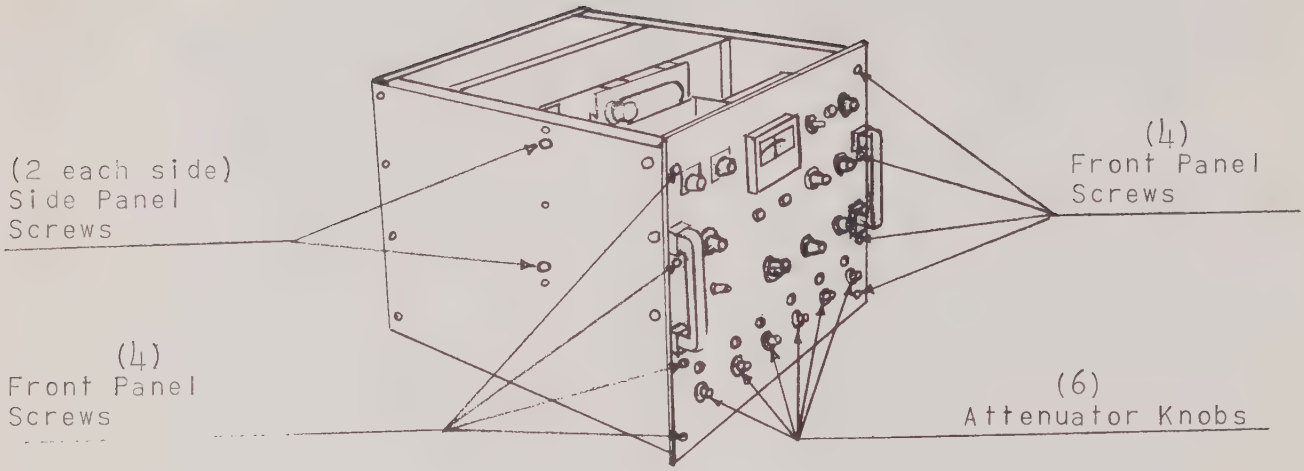
INSTALLATION INSTRUCTIONS

1. Remove the cabinet.

2. Install the rack mounting brackets (54278 and 54279) as shown in the above diagram. Be sure they are flush with the front panel. Secure with the 10-32 x 1/2" flat head screws.

3. Install the slides on each side following the instructions supplied by the manufacturer with each pair of slides.

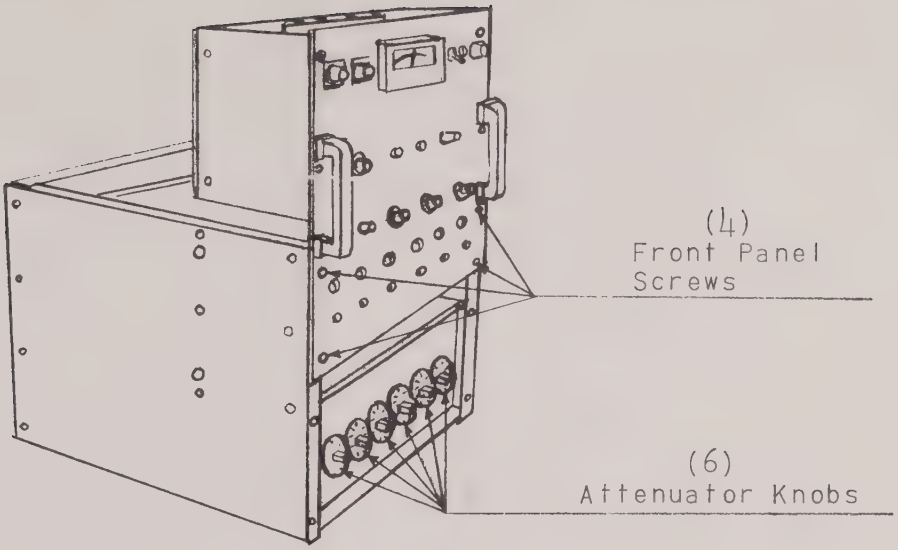
4. Position the top cover on the unit and secure with the 6-32 x 3/8" truss head screws and lockwashers.



NORMAL POSITION

In some situations requiring service of the Model 10 it may be advantageous to raise the front panel and main circuit board assembly to an elevated position. This will allow easy access to the main circuit board, null-detector and the oven assemblies. Use the following procedure:

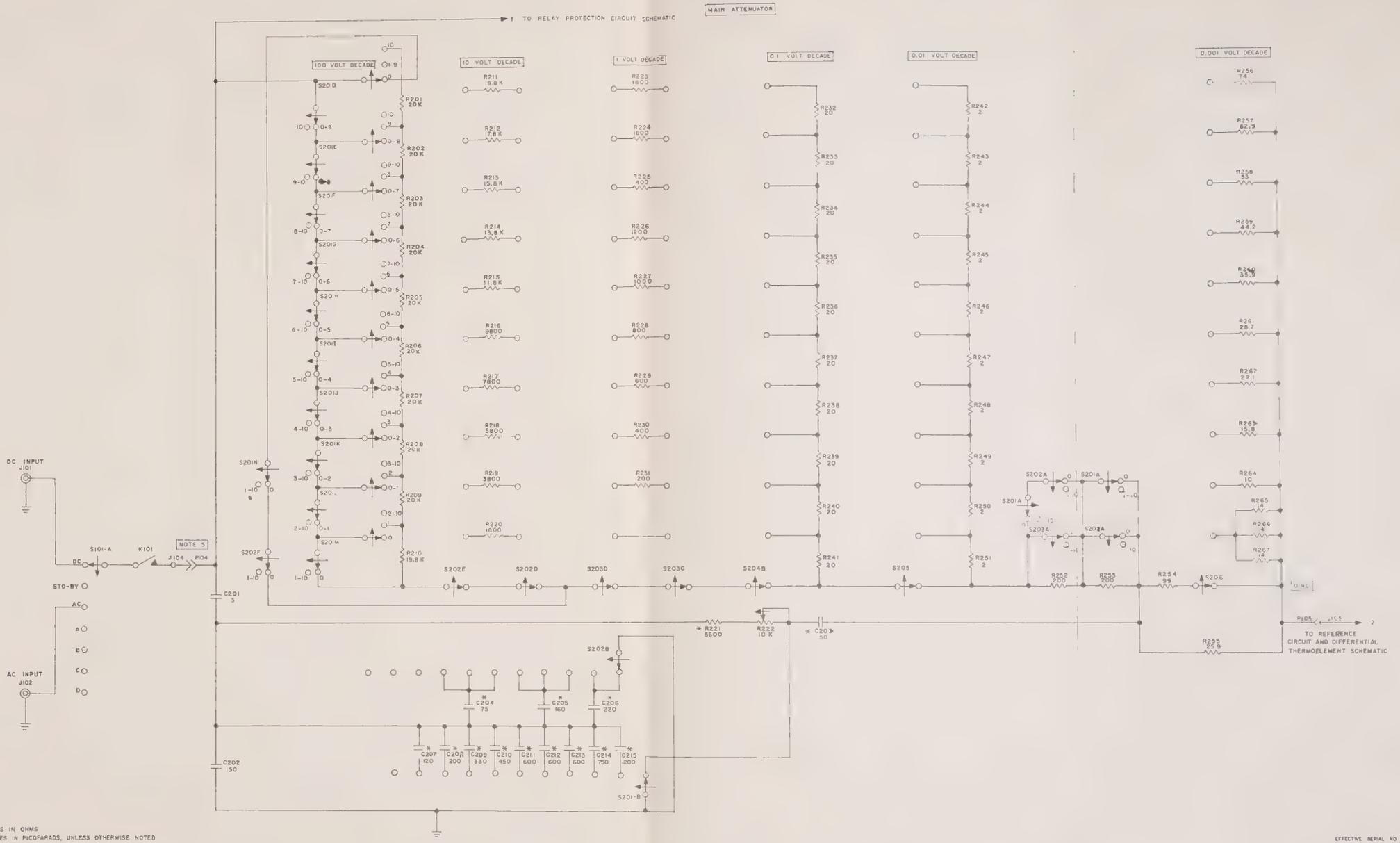
1. Remove the dust cover.
2. Remove the bottom cover.
3. Remove the attenuator knobs.
4. Remove the (8) front panel screws.
5. Remove the (4) side panel screws indicated by the arrows from the left and right sides.
6. With the instrument turned upside down, remove the (4) screws holding down the angle bracket attached to the main circuit board. These are identified by a dot of red glyplal on the chassis next to them in the attenuator.
7. Turn the instrument right side up. Disconnect P104 and P105. See figure 19, page 6-3.
8. Pull the front panel out far enough to clear the attenuator knobs and raise the assembly to position shown in Service Position figure. Attach the front panel to the chassis with (2) front panel mounting screws by



SERVICE POSITION

aligning the two top chassis captive nuts on each side and the bottom two front panel holes on each side.

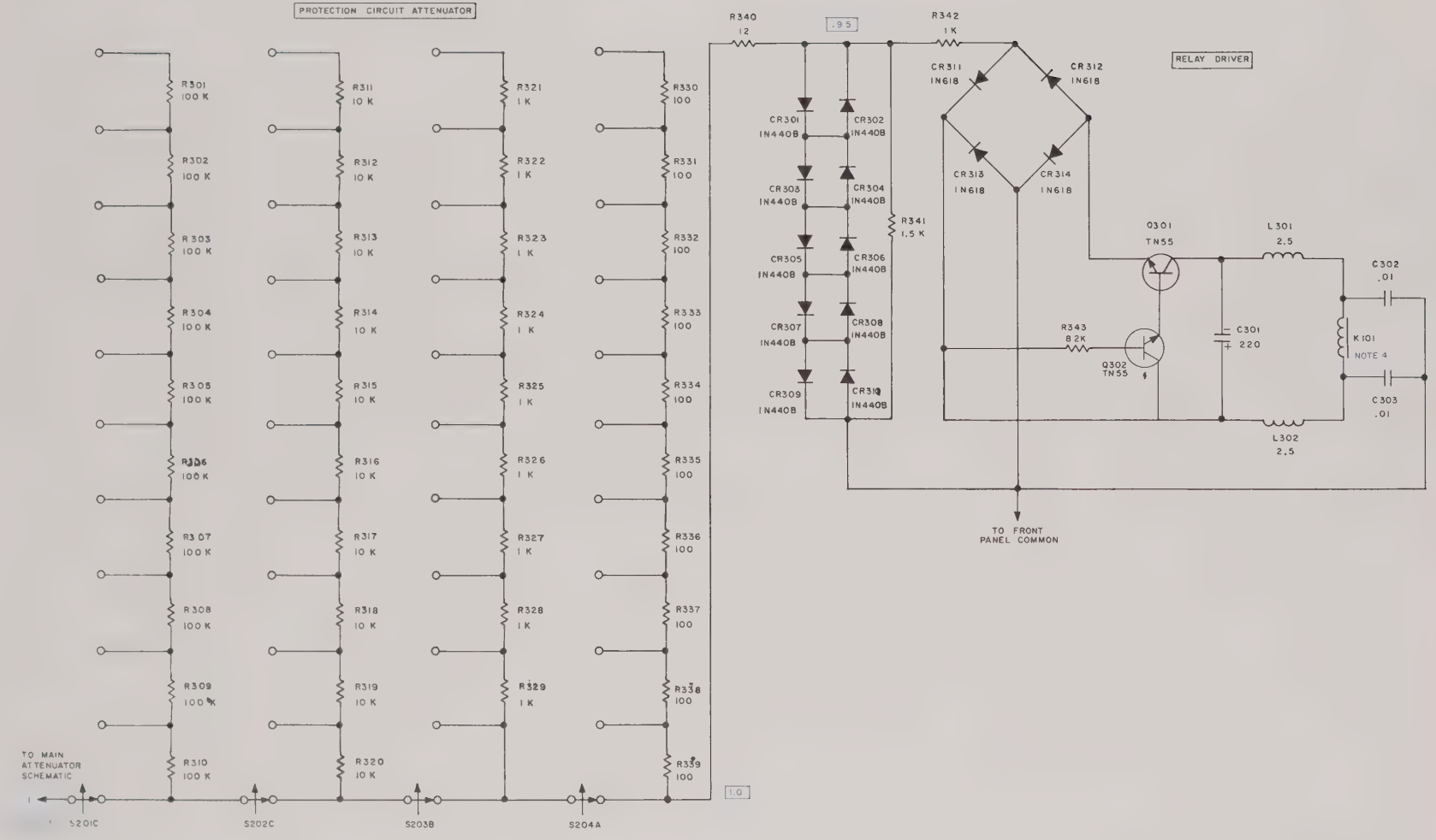
CAUTION: Do not attempt to turn the attenuator switches when the knobs are removed by grasping the dials. The dials may be damaged by applying torque to them.



NOTES: 1. ALL RESISTOR VALUES IN OHMS
2. ALL CAPACITOR VALUES IN PICOFARADS, UNLESS OTHERWISE NOTED
3. * FACTORY SELECTED
4. [ ] EITHER +DC, −DC, OR AC VRMS.
5. EQUAL TO 100% OF THE SELECTED RANGE AT NULL
6. VOLTAGE READINGS TAKEN WITH FUNCTION SWITCH IN AC OR DC POSITION WITH METER NULLED

EFFECTIVE SERIAL NO 103

SCHEMATIC DIAGRAM
MAIN ATTENUATOR
MODEL 10
HOLT INSTRUMENT LABORATORIES



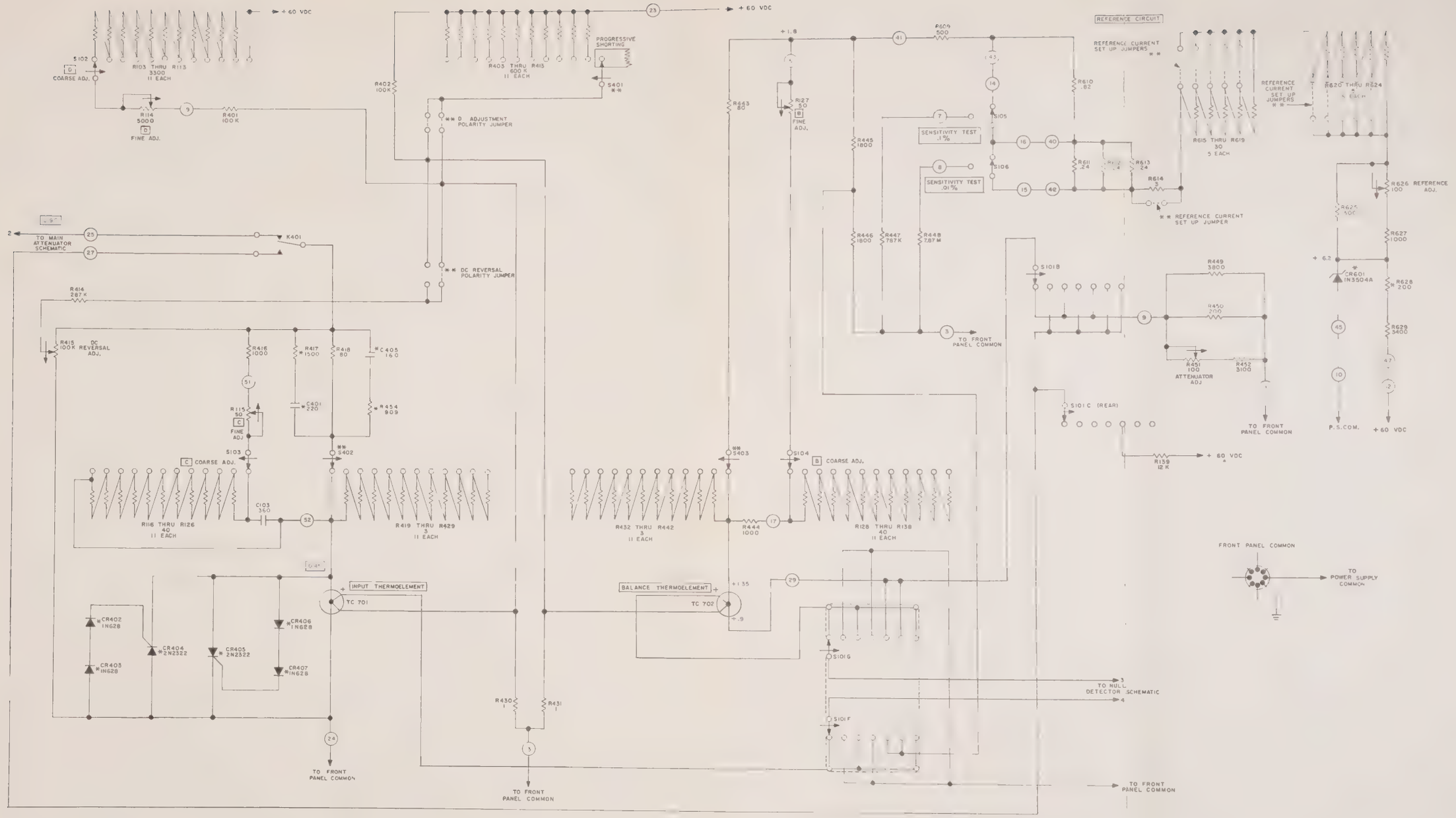
1. ALL INDUCTOR VALUES IN MILLIHENRYS UNLESS OTHERWISE NOTED.
2. ALL RESISTOR VALUES IN OHMS.
3. ALL CAPACITOR VALUES IN MICROFARADS UNLESS OTHERWISE NOTED.

EFFECTIVE SERIAL NO 100

SCHEMATIC DIAGRAM
OVERLOAD RELAY
PROTECTION CIRCUIT

MODEL 10

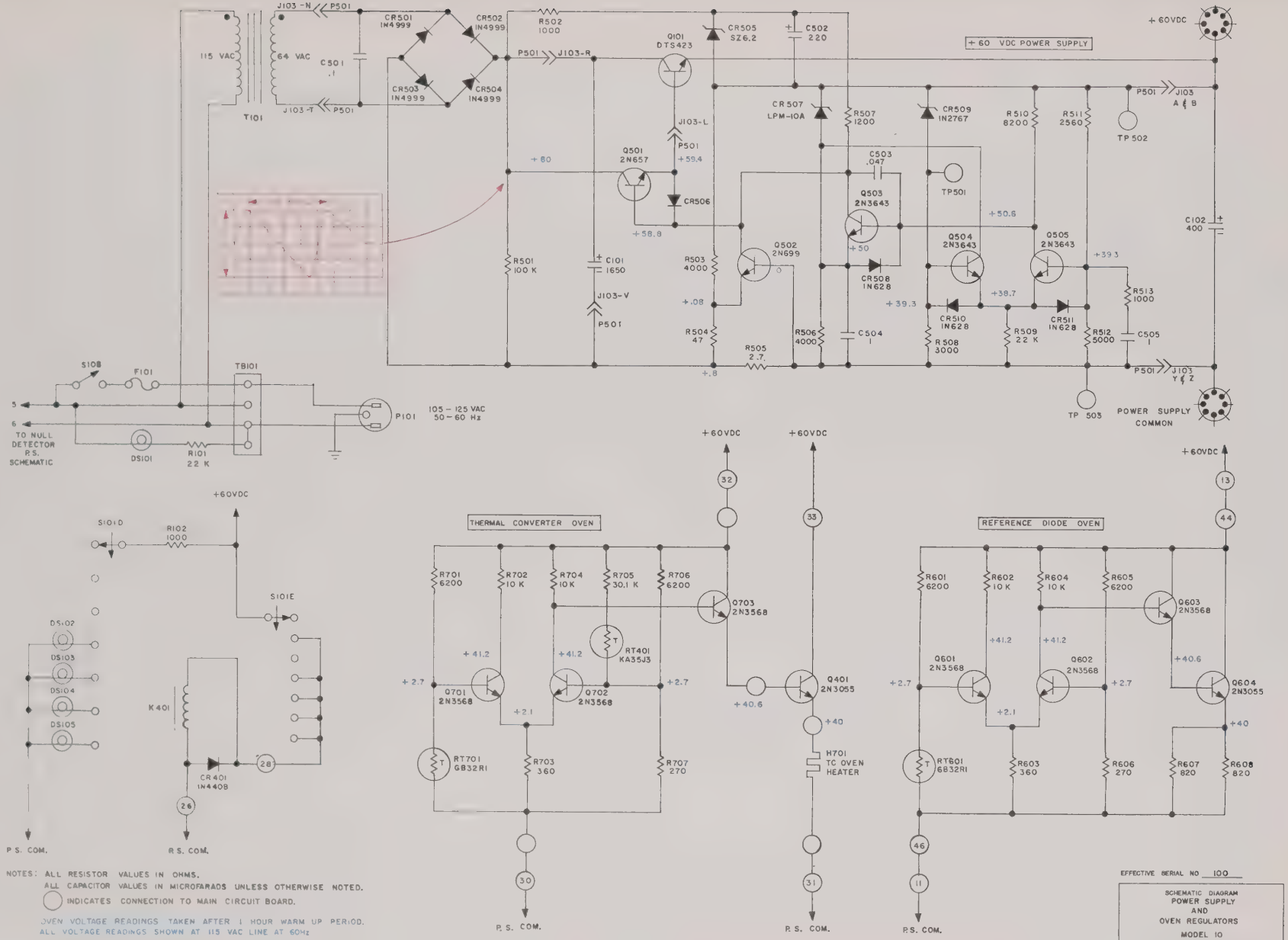
HOLT INSTRUMENT LABORATORIES



NOTES
** FACTORY ADJUSTMENTS
* FACTORY SELECTED VALUES
ALL RESISTOR VALUES IN OHMS
ALL CAPACITOR VALUES IN PICOFARADS UNLESS OTHERWISE NOTED
INDICATES CONNECTION TO MAIN CIRCUIT BOARD
EITHER +DCV, -DCV OR AC VOLTS R.M.S.
ALL VOLTAGE READINGS TAKEN WITH FUNCTION SWITCH IN AC OR DC POSITION WITH METER NULLED

EFFECTIVE SERIAL NO 103

SCHEMATIC DIAGRAM
REFERENCE CIRCUIT AND DIFFERENTIAL THERMOELEMENT
MODEL 10
HOLT INSTRUMENT LABORATORIES

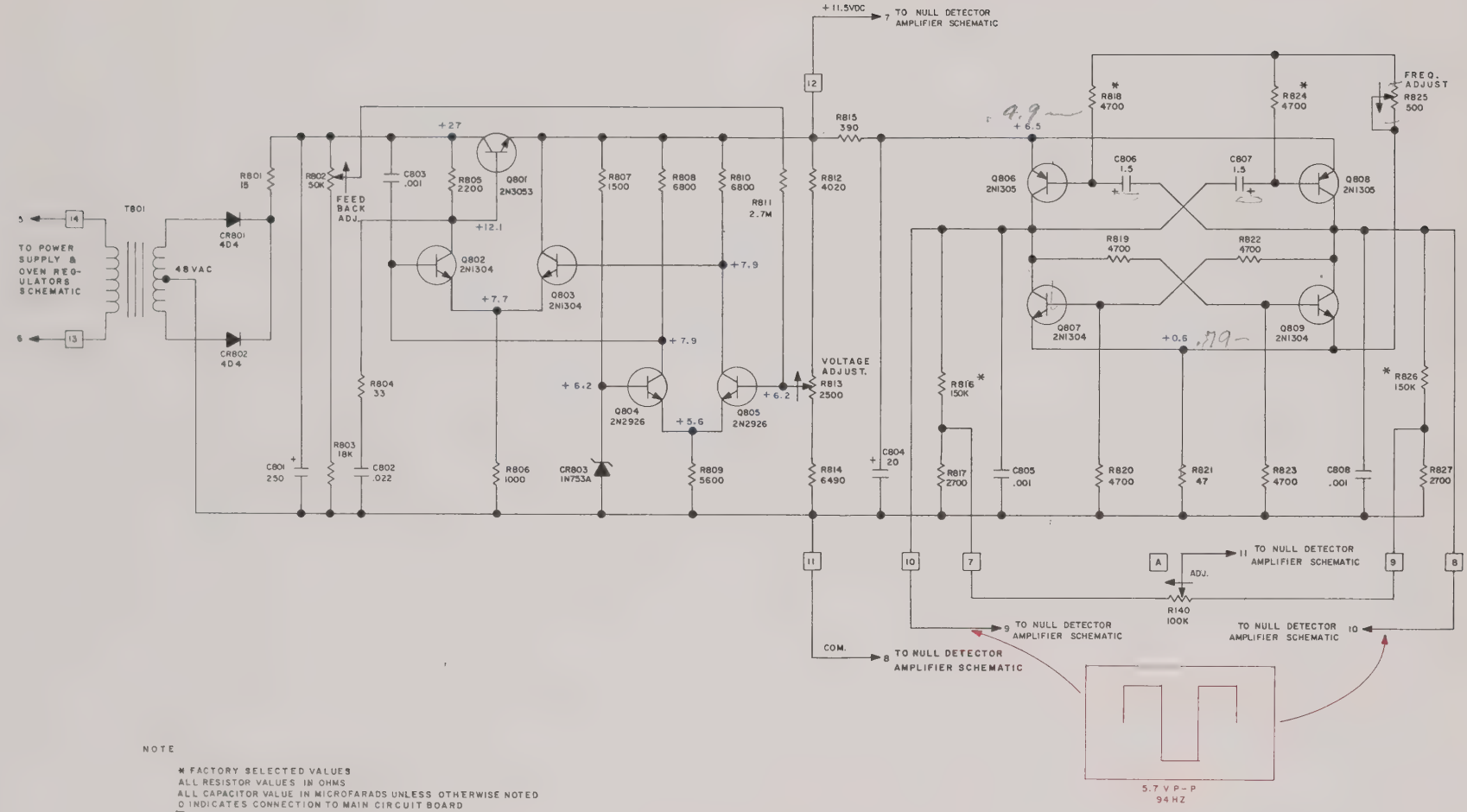


NOTES: ALL RESISTOR VALUES IN OHMS.
ALL CAPACITOR VALUES IN MICROFARADS UNLESS OTHERWISE NOTED.
◯ INDICATES CONNECTION TO MAIN CIRCUIT BOARD.

OVEN VOLTAGE READINGS TAKEN AFTER 1 HOUR WARM UP PERIOD.
ALL VOLTAGE READINGS SHOWN AT 115 VAC LINE AT 60Hz

EFFECTIVE SERIAL NO 100

SCHEMATIC DIAGRAM
POWER SUPPLY
AND
OVEN REGULATORS
MODEL 10
HOLT INSTRUMENT LABORATORIES

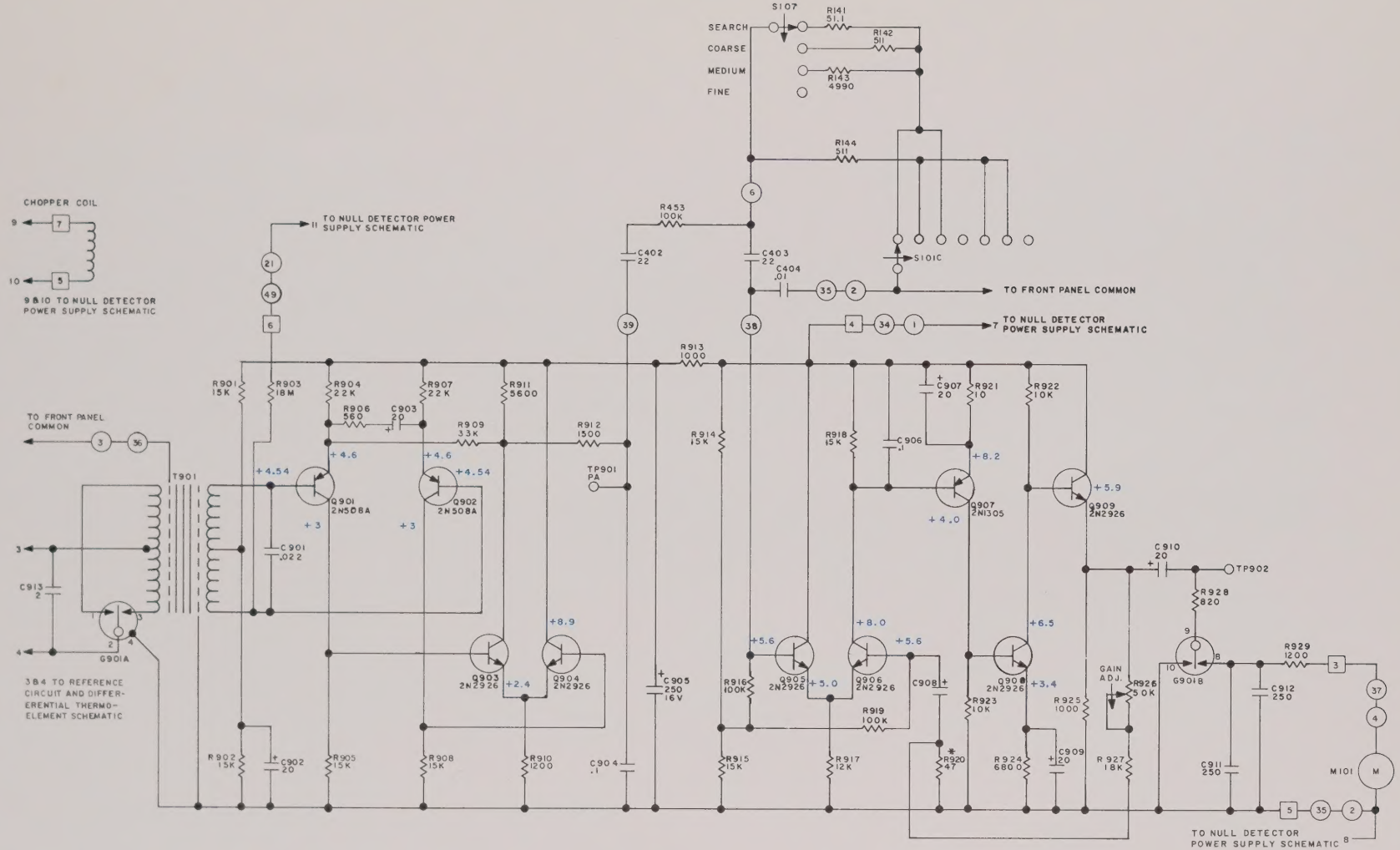


NOTE

* FACTORY SELECTED VALUES
ALL RESISTOR VALUES IN OHMS
ALL CAPACITOR VALUE IN MICROFARADS UNLESS OTHERWISE NOTED
O INDICATES CONNECTION TO MAIN CIRCUIT BOARD
□ INDICATES CONNECTION TO NULL DETECTOR BOARD

EFFECTIVE SERIAL NO 103

SCHEMATIC DIAGRAM
NULL DETECTOR
POWER SUPPLY
MODEL 10
HOLT INSTRUMENT LABORATORIES



NOTE:

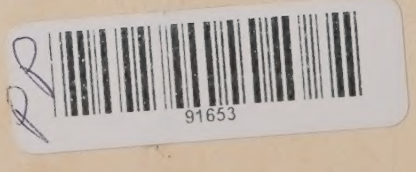
* FACTORY SELECTED VALUES
ALL RESISTORS VALUES IN OHM
ALL CAPACITOR VALUES MICROFARADS UNLESS OTHERWISE NOTED
○ INDICATES CONNECTION TO MAIN CIRCIT BOARD
□ INDICATES CONNECTION TO NULL DETECTOR BOARD

EFFECTIVE SERIAL NO. 103

SCHEMATIC DIAGRAM

NULL DETECTOR AMPLIFIER MODEL 10

HOLT INSTRUMENT LABORATORIES
OCONTO, WISCONSIN


91653